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## PRESENT STATE OF THE INTRACAPSULAR CATARACT OPERATION

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NEW YORK

THE IDEA of removing the cataract in its capsule has interested ophthalmic surgeons for many years, but it was not until Henry Smith, in 1903, accepted the opportunity, offered by the many sufferers from cataract in India, to develop an intracapsular technic that a new era began in cataract surgery. While the advantages of removing the capsule and the lens cortex in the cataract operation were apparent to every one, the difficulties and complications of this new procedure were soon recognized, and attempts to overcome them became the task of an ever increasing number of operators.

The success of these attempts has been most encouraging, the intracapsular operation has gained steadily in favor and is now practiced by an increasing number of surgeons. An analysis of these efforts and a critical examination of the intracapsular operation of the present day are the purpose of this address.

The history of the intracapsular cataract extraction goes back many years. At the Amsterdam Congress, in 1929, Marquez spoke of a book published in 1789 in which the intracapsular extraction with forceps was described<sup>1</sup>. About 1850, McNamara, of Calcutta, practiced a method of intracapsular extraction by combined external pressure applied just back of the incision with the curet and at the opposite limbus with the tip of the finger, and Wright, of Columbus, Ohio, described a similar method at about the same time.

The two Pagenstechers<sup>2</sup> stated their belief that the remaining capsule and remnants of the lens in the usual cataract extraction were the principal causes of iritis and practiced a method of removing the lens in its capsule by introducing a spoon back of the lens and extracting

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1 Pellier de Quengsy. *Precis du cours d'operations sur la chirurgie des yeux*, Paris, Didot & Mequignon, 1789-1790.

2 Pagenstecher, A. *Klinische Beobachtungen aus der Augenheilanstalt zu Wiesbaden*, Wiesbaden, J. Niedner, 1866.



the lens, with the loss of a few drops of vitreous De Wecker<sup>3</sup> operated in 66 cases and then abandoned the procedure Terson, in 1872 and 1887, reported that he extracted the cataract by applying external pressure after grasping the capsule of the lens with a special forceps Molroney, of India, in 1894, practiced a method similar to McNamara's

According to Smith,<sup>4</sup> the intracapsular method would have been lost with Molroney, as he never wrote on the subject, if someone else had not come on the scene Smith was led to try intracapsular extraction after he had observed in operations on nervous patients under cocaine anesthesia that occasionally, on completion of the incision, the patient, in screwing up the orbicularis muscle, shot out both the lens in its capsule and a quantity of vitreous To his agreeable surprise, the results in these operations were generally good In 1903, Smith<sup>5</sup> published a report of 6,500 intracapsular operations, and the era of the intracapsular extraction began

But the operation of extracting the cataract in the capsule by external pressure alone did not find many followers because of complications, of which loss of vitreous was the principal factor, and other attempts to obtain the same results were soon made These consisted in grasping the anterior capsule either with the forceps or by means of a suction apparatus

The first step in the intracapsular extraction was the subluxation of the cataractous lens by rupture of the zonular fibers which support the lens In this step two structures were encountered, namely, the zonule and the capsule

#### ANATOMIC RELATIONS

*Ciliary Zonule*—Three anatomic features of the zonule are important in this connection (1) the origin of the fibers, (2) the independence of the zonular membrane of the hyaloid part of the vitreous and (3) the insertion of the zonular fibers into the capsule of the lens The zonular fibers arise from the pigment epithelium and the plane portion of the ciliary part of the retina They are cemented together by a translucent substance to form the ciliary zonule, or suspensory ligament and pass across the perilenticular space to divide into two leaves, which become attached, respectively, to the anterior and the posterior capsule of the lens In addition, some fibers are attached to the equator of the lens, but they are not strong and hence do not play any role in the intracapsular extraction Though the zonule fits into the curved surface of the posterior third of the ciliary processes, it is independent and can be easily detached without injury to the pigment cells, except where

3 de Wecker *Traite theorique et pratique des maladies des yeux*, ed 2, Paris, A Delahaye, 1866-1867, p 22

4 Smith, H *The Treatment of Cataract and Some Other Common Ocular Affections*, London, Butterworth & Company, 1928, p 209

5 Smith, H *Extraction of Cataract in the Capsule*, Brit M J 2 719, 1903

it becomes firmly united to the ciliary portion of the retina, then large pieces of retinal epithelium are pulled off in its separation

On its internal surface the zonule is in contact with the hyaloid membrane of the vitreous body, but it is quite independent, as they are two different structures. The hyaloid membrane comes in contact with the ciliary crests through the intermediary role of the zonule and passes like a bridge over the valleys. At the plane portion the zonule separates the hyaloid membrane from the retina, while at the ora serrata the retinal epithelium and the hyaloid are united. The ciliary processes are in contact with the suspensory ligament only in their posterior portion. Hence, total extraction has no deleterious action, as rupture of the fibers takes place close to their capsular insertion.

Beauvieux found that the fibers were torn at the level of the walls of the canal of Hannover and that therefore some very short zonular fringes remained, with or without tearing a portion of the zonular layer of the lens capsule.

The zonule becomes friable with advancing years, and the readiness of its rupture is proportional to the age of the patient; up to a certain age the zonule retains its elasticity, and rupture does not occur readily.

*Lens Capsule*—The capsule of the lens is a clear structureless membrane, which is thicker in its anterior than in its posterior layer. The thickness of the capsule varies in different parts of the lens.<sup>6</sup> On both the anterior and the posterior surface there is a circular zone of maximal thickness running concentrically with the equator a short distance axial to the insertion of the zonular fibers. The thickest part anteriorly is in a region 3 mm distant from the anterior pole, while the thinnest part is at the exact center. There is an adhesion between the posterior layer of the capsule and the vitreous in the form of a ring 8 to 9 mm in diameter, this is known as the hyaloid-capsular ligament and is extremely thin.

Though it is generally easy to remove the lens from its hyaloid (patellar) fossa, I have found sometimes at operation that an adhesion was present. The fibers of the suspensory ligament are inserted into the zonular layer of the capsule, in a zone concentric with and at a short distance from the equator on the anterior and the posterior surface. The zone of insertion is broader on the anterior surface than on the posterior surface, in the ratio of 3 to 2, and with advancing years there is a gradual increase in thickness of the capsule throughout.

It is natural that the more elastic the capsule the more difficult it is to rupture. Though the thinnest part of the capsule is at the posterior pole, rupture at this place seems to be infrequent.<sup>7</sup> It is well known

6 Duke-Elder, W. S. Text-Book of Ophthalmology, St. Louis, C. V. Mosby Company, 1932, vol. 1, p. 132.

7 Rotth, A., and Klein, N. Die Linsenkapsel bei der intrakapsulären Star-operation, Klin. Monatsbl. f. Augenh. 84: 823, 1930.

that after iridocyclitis the capsule thickens, and at operation it can be easily grasped and the cataract extracted in its capsule. In fact, this form of intracapsular extraction antedated the time when the intracapsular extraction was done for the usual senile cataract.

Other peculiarities of the capsule depend on the consistency of the cataract, which plays an important role from an operative standpoint, and an important one of these is the tenseness of the capsule. If the capsule is tense, it is impossible to grasp it, the forceps slips off, and if a hold is obtained the capsule is apt to rupture, this tenseness of the capsule occurs in the cases of swollen cataract and of the hard cataract in which the nucleus lies directly under the capsule.

The lens and its suspensory ligament are in contact only with the vitreous body, and the vitreous body is adherent to the underlying structure only in the region of the ora serrata. Hence, it is explainable how easily the lens can be removed in its entirety without fearing loss of vitreous. In anatomic dissections the hyaloid membrane is separated with great facility from the posterior zonular membrane. In fact, anatomists described a potential space (Petit's space) between the posterior zonular membrane and the hyaloid membrane which sometimes contained blood or inflammatory products.

Beauvieux<sup>8</sup> repeatedly attempted to extract the crystalline lens and its capsule in enucleated eyes by the posterior surface and was surprised to observe that unusual resistance existed. On the other hand, gentle and continuous traction on the anterior surface of the lens resulted in rupture of the zonular fibers without requiring a great deal of effort.

Troncoso,<sup>9</sup> in 1936, recommended the anatomic method of examination with the slit lamp microscope for a stereoscopic view of the architecture of the zonule and of the surrounding tissues in specimens stained with Flemming's solution. The dissection was made under water, as this in no way disturbed the position and relation of the various tissues.

Goldsmith<sup>10</sup> examined microscopically 2 eyes that had undergone the intracapsular operation and found no evidence of a tear of the hyaloid membrane or of any traumatism to the ciliary epithelium, thus substantiating Verhoeff's<sup>11</sup> observations.

In an anatomic examination of 50 human eyes obtained shortly after death, Goldsmith found that the vitreous body was easily detached

8 Beauvieux. *La zonule*, Arch d'opht 39 410, 1922

9 Troncoso, M U, in discussion on Goldsmith,<sup>10</sup> p 430, *Intrascleral Vascular Plexus and Its Relation to Aqueous Outflow*, Am J Ophth 25 1153, 1942

10 Goldsmith, J. *Dynamics of Intracapsular Cataract Extraction. Experimental Studies with Reference to Suspensory Ligament, Hannover's Canal and Petit's Space*, Arch Ophth 29 380 (March) 1943

11 Verhoeff, F H. *Conditions of the Ocular Structures Immediately After Removal of the Lens in Capsule as Determined by Microscopic Examination*, Tr Am Ophth Soc 29 184, 1931

from the posterior zonular membrane and from the posterior surface of the lens but that a slight resistance was encountered at the retro-equatorial region of the lens. After section of the suspensory ligament, the attempt to draw the lens forward met with decided resistance, and the separation occurred slowly, but if the attempt was made to deliver the lens tangentially the separation succeeded easily, and after extraction a large depression was noted, which corresponded to the hyaloid fossa. This confirms the experience of intracapsular operators that the lens cannot be drawn forward from the hyaloid fossa but that it can more easily be dislodged tangentially. This has led to the practice of side to side movements of the lens in the subluxation maneuver of the forceps operation.

### STEPS IN THE INTRACAPSULAR OPERATION

The primary step in the intracapsular operation is the subluxation of the lens by rupture of the suspensory ligament. The facility of this rupture depends on the state of the suspensory ligament and of the capsule of the lens, and it may be said that the success of the intracapsular extraction rests on two factors—the capsule of the lens and the zonular fibers and on their relation.<sup>12</sup> The capsule thickens up to the age of 35 to 40 years, and the resistance of the zonular fibers is reduced with age, though there may be individual differences. The adhesion between the capsule of the lens and the hyaloid membrane loosens as the vitreous body retracts with age (Arruga). The weakest point of the zonular fibers is at the capsular insertion. In the capsule, thickness, tenseness and elasticity are important, and, as has been mentioned, the capsule is thickest in an area between the equator and the poles, at the poles it is thin.

The clinical varieties of the cataract are also of moment in the process of subluxation, and extraction is easiest in the case of the sclerosed lens and of the soft mature or nearly mature cortical cataract, less favorable are the hard, the large nuclear and the hypermature cataract. Least favorable is the intumescent cataract. The most important changes in the zonule and in the capsule are due to age and are exemplified in their most extreme stage in the frequent dislocation of the morgagnian cataract, on the other hand, the elasticity of the suspensory ligament in the young resists all reasonable attempts at dislocation.

In short, the older the patient, the easier the subluxation, hence, intracapsular extraction is not suitable for young patients, and that means, generally speaking, persons under 45 years of age. The capsule in the intumescent, or immature, stage of the nonsclerosed type of

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12 Rotth, A. Ueber die anatomischen Grundlagen der kapsulären Kataraktextraktion, *Orvosí hetil* **11** 1238, 1930, abstracted, *Zentralbl f d ges Ophth* **25**:59, 1931.

cataract is tense and thin and is liable to rupture during the attempt at subluxation

Attempts have been made to determine with the slit lamp the suitability of a cataract for intracapsular operation, and Rohrschneider<sup>13</sup> stated that the presence of water clefts makes the cataract unsuitable for the intracapsular operation in a large proportion of cases and that the nuclear and posterior cortical varieties are all suitable for this operation, as well as those with subcapsular vacuoles and coronaria opacities. The most important point is the patient's age, and the best results are in persons over 60 years of age.

Meissner expressed the opinion that cataracts complicated with old iritis were particularly suitable for the intracapsular extraction and suggested that an iridectomy be first done and the adhesions separated, while Smith and Stock did not think it necessary to separate the adhesions. While knowledge of the friability of the zonule and the thickness of the capsule would be of advantage to the operator, there is at present no way, by examination with the slit lamp or by any other means, to obtain this information.

A number of ways have been devised to effect subluxation. The first was that of Henry Smith, which consisted in external pressure on the eyeball. Pressure exerted straight back on the lower half of the cornea caused the head of the lens to present, while pressure in the lowest periphery, in a downward direction, caused the lens to somersault. Thus, Smith devised two methods of subluxation according to the consistency of the cataract, and, from an operative standpoint, he divided cataracts into hard and soft.

The attachment of the suspensory ligament was weaker in the soft than in the hard types; in both types the attachment weakened with

to hard cataracts. Pressure was applied straight back in the lower third of the lens with a small tenotomy hook applied flat, by which means, when pressure was exerted with the elbow of the hook, the intraocular pressure was raised and the ligament was ruptured by pressure with the tip of the instrument.

With the second, or soft, variety the head-first delivery was easier, but the capsule ruptured too frequently. This was avoided by exerting pressure with the hook downward, as though trying to pull the patient's eye toward his feet; the lens rolled upward, becoming dislocated at the lower edge first, and then, as a result of following up the turning movement with the tip of the hook, the lens was delivered "feet first" and its attachment above was finally peeled off.

13 Rohrschneider, W. Die Virwurtung der Spatlampenbefundes an der Linse bei der Indikationsstellung zur intrakapsularen Extraktion, *Ber ü d Versamml d deutsch ophth Gesellsch* 53 182, 1940

Smith laid down the fundamental rule, applicable to all methods, that the lens must be made to swing round on a transverse axis, so as to concentrate the strain on the suspensory ligament at one or two points. When the ligament gave way at this point and the lens was dislocated from the hyaloid fossa, then, and then only, could the lens be removed from the eye.

The Smith method of subluxation of the cataract by external pressure alone requires great delicacy, lightness of hand and dexterity. As these attributes are not common to all operators, other methods of subluxation have been suggested.

The first of these to be considered is the principle of suction, by which a hold on the anterior capsule is taken with a cup-shaped device. The Hulen apparatus did not gain recognition, and the principle was forgotten until Barraquer<sup>14</sup> devised an apparatus which consisted of an electrically driven pump, a most ingeniously designed instrument, and a suction cup. The cup is applied to the capsule of the lens, which is brusquely contracted by suction through the pump action, and the zonular fibers are ruptured as the cannula is rotated in the arc of the incision, without traction on the ciliary body. The cataract is then lifted out of the hyaloid fossa, by turning the handle on its axis, without deforming the vitreous, and is withdrawn from the anterior chamber either by suction or by slight pressure on the cornea. The section need not be larger than in the ordinary operation, i. e., two fifths of the corneal circumference. The iridectomy must be peripheral but large enough to prevent prolapse. The intensity of the vacuum can be regulated, but it is important that the cup close firmly and that the mechanical action of the pump be carefully looked after.

The technic of applying suction with the cup is delicate and difficult. If the intensity of the vacuum is too great, the capsule ruptures, if too little, the apparatus slips from the cataract. The extraction is performed either head first or by tumbling, the latter technic is better and involves fewer accidents. Complications are due to poor application of the cup, to an incorrect gage or to the wrong choice of diameter of the cup. Accidents are avoided by causing the superior border of the cataract to glide exactly in the curvature of the hyaloid fossa, without exerting any pressure. It is important that the suction cup be of suitable size and that the lens first be dislocated into the anterior chamber before extraction is attempted.

The Barraquer procedure was objected to because the electric pump was found too complicated. In my hands, the pump's action was not

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14 Barraquer, I. (a) La suture cornéo-sclérale dans l'extraction totale de la cataracte sénile, *Ann. d'ocul.* **176**:470, 1939, (b) Dangers of Capsulotomy and Advantages of Complete Extraction, *Arch. Ophth.* **50** 307, 1921.

easily controlled and therefore became dangerous. The Greens have simplified the principle of the pump. Though the suction cup takes hold of some capsules better than other means, the procedure has not been generally adopted.

Some authors have replaced the Barraquer apparatus with a glass syringe with a special cup (Argañaraz<sup>15</sup>). The zonular fibers are torn tangentially by moving the syringe from one end of the incision to the other, then lateral and anterior movements are added, and finally the extraction of the lens occurs, after a rotation of 180 degrees.

On the occasion of a visit to Colonel Smith, in Jullunder, India, in 1908, I was impressed with the greater safety of the tumbling maneuver as compared with the head-first extraction. On returning home, my efforts with the Indian technic were not satisfactory, as I failed to sublunate the cataract with the amount of manipulation which I thought was justifiable, and I returned to the capsulotomy procedure.

On using the Kalt forceps, which was devised by its author for capsulotomy and is constructed like a bifurcated cup, with blunt edges and branches, bent on the model of a Telson toothed-capsule forceps, I found that, with a little care, the lens could be sublunated at one point without tearing the capsule. The anterior capsule was grasped under the iris in the lower third, and, after manipulation, sublunation took place below. When this sublunation of the lens had taken place, and the lower margin of the cataract appeared in the pupillary area, fearing that further traction with the forceps would tear the capsule, I released the capsule forceps.

Pressure straight back was then applied at the lower corneal margin with Smith's blunt tenotomy hook, and, with counterpressure above at the scleral edge of the incision, the lens in its capsule was made to tumble, with continued pressure below, and directed partly upward, the lower margin of the lens traversed the anterior chamber and presented in the section. After delivery of the equator, the lens was easily extracted by separating the adhering suspensory attachment above. I performed the first operation according to this technic in February 1910.

A report by Stanculeanu was made in August 1910, at the Heidelberg meeting of the German Ophthalmological Society, describing a similar method of intracapsular extraction with the Manolescu forceps, but no details of the operation or results were given until Stanculeanu's<sup>16</sup> article appeared, in 1912, describing his method. He used the reverse sides of a blunt-tipped iris forceps and grasped as large a fold of capsule as possible. Then, with lateral movements and some traction

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15 Argañaraz, R. La extracción de la cataracta senil par medio de la ventosa a mano, vacuo avulsion o facoerisis, Arch de oftal de Buenos Aires **12** 609, 1937.

16 Stanculeanu, G. Intrakapsulare Staroperationen, Klin Monatsbl f Augenh **50** 527, 1912.

upward, the lens with its capsule was separated from the zonule. When this occurred, the forceps was released. Pressure with two spatulas in the usual manner brought about the extraction. This resembled the procedure which I followed except that with my method stress was laid on avoiding a head-on delivery by grasping the capsule as low as possible, so as to sublunate the lens below, and then tumbling the lens.

Descriptions of various intracapsular procedures then began to make their appearance in ophthalmologic literature, with lessening attention to the Indian method of extraction by external pressure and with increasing interest in the forceps extraction.

Torok,<sup>17</sup> who at that time was connected with the Heiman Knapp Memorial Eye Hospital modified the forceps extraction by grasping the capsule in its upper half with the Kalt forceps and, with pressure exerted below, expressed the lens head first, the forceps keeping hold of the capsule throughout the extraction. Verhoeff found that the expression of the cataract was facilitated by the addition of external pressure. Smith had always drawn attention to the importance of external pressure, by which the tension of the vitreous was increased and subluxation of the cataract facilitated.

I have gone over Torok's cases in the hospital records, with his permission and have found that during a similar interval of time with his procedure the number of ruptures of the capsule during the process of delivery was 12 per cent, while in my series it was 6 per cent. Rupture of the capsule during delivery is an unpleasant complication, as it requires the removal of the capsular bag separately, which is often difficult, especially in the presence of escape of vitreous.

Verhoeff is opposed to tumbling, as it deforms the vitreous. De Grösz<sup>18</sup> expressed the belief that with the tumbling of the lens loss of vitreous is more frequent, that there are more instances of expulsive hemorrhage and that in after years the pupil becomes distorted, he expressed preference for the head-on delivery, as it is easier and simpler.

While I personally prefer the process of tumbling, as it is the safer method, the addition of external pressure has succeeded in dislocating a larger percentage of cataracts. This has led to the adoption of the following procedure. The lens capsule is grasped at its lowest part, moderate traction is exerted in various directions, with simultaneous external pressure with the Smith hook at the inferior margin of the cornea until dislocation below has taken place and the lower margin of the cataract appears in the pupil, this is followed by release of the forceps and extraction of the partly sublunated lens, by external pressure,

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17 Torok, E. Extraction of Cataract in the Capsule by a Slight Modification of the von Graefe Method, *Tr Am Ophth Soc* **14** 482, 1916.

18 de Grösz, E. Quelques mots sur la technique de l'extraction intracapsulaire de la cataracte, *Ann d'ocul* **175** 320, 1938.



with the hook below and counterpressure above, and the cataract is made to tumble and to be delivered lower edge first

While on the whole the advantages of the tumbling maneuver have been accepted by most operators, it is generally believed that the hold of the forceps on the anterior capsule should be maintained throughout the operation I<sup>19</sup> have shown that the greater resulting leverage which was thereby exerted on the capsule of the lens during the tumbling maneuver resulted in a greater frequency of rupture of the capsule, particularly in nonpliable cataracts

Recognizing the value of the tumbling maneuver, and realizing the difficulty of delivering hard lenses as tumblers solely by pressure from without, Smith,<sup>20</sup> in 1926, modified his method as follows A squint hook was first applied over the sclera at 6 o'clock, and with pressure the tension of the vitreous was raised to the point required for dislocation To prevent the lens from moving to the middle of the incision and the zonule giving way first at this point, a broad spatula was placed on flat over the incision, which closed the incision and kept the lens from shifting upward The hook was then pressed straight back over the sclera below, to make the zonule give way at this place The lower border of the lens tumbled and came forward, swinging about a transverse axis The pressure was then partly relaxed, and the hook pushed the cornea in below and behind the lens The spatula was removed from the area of the incision above, and the lens then slowly appeared With the soft cataract this spatula maneuver was not necessary, as the lens molded and readily made its exit Smith expressed the opinion that this method of extracting hard and soft lenses as tumblers would replace all methods of intracapsular extraction with vacuum spoon or forceps

Sinclair<sup>21</sup> devised another way to prevent the upper edge of the lens from coming forward before the lower edge is dislocated, by using a capsule forceps with a fenestrated flange at the base of the branches The heel gives support to the scleral lip of the wound during the first stage of dislocation of the lower margin of the lens This support is released as soon as the subluxation of the lens has been accomplished, i e., when the lower part of the lens is seen to rise into the pupil External pressure is applied over the sclera 2 mm below the limbus by a special instrument called a repositor (a wire grid) When the lens is subluxated, the direction of pressure is changed, and the direction of

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19 Knapp, A On Methods of Dealing with Capsule in Cataract Extraction, *Arch Ophth* 50 115, 1921

20 Smith, H New Technique for Expression of Cataractous Lens in Its Capsule, *Arch Ophth* 55 213, 1926

21 Sinclair, A H H Intracapsular Extraction of Cataract, *Tr Ophth Soc U Kingdom* 52 1vii, 1933

traction becomes somewhat oblique with release of pressure with the flange. In my hands this maneuver led more frequently to rupture of the capsule.

Mendoza<sup>22</sup> found that in the intracapsular extraction there is danger of the cataract slipping into vitreous on the operator's attempting to grasp the capsule. To prevent this, he exerted pressure with the knee of the forceps against the upper margin of the incision as the hook was applied below. The lens was then caught between the forceps and the hook, and the capsule was easily seized.

Smith objected to any capsule forceps because it was not flexible and was apt to fail during the operation, by tearing the capsule or by losing its grip. He was not in favor of any attempt to pull out the lens by main force, as a strain put on the suspensory ligament all around could not succeed in subluxating the lens. In the intracapsular extraction the lens must swing on a transverse axis so as to concentrate the strain on one or two points. When the ligament has given way at one point, the lens can then be dislocated from the hyaloid fossa, and then only can it be removed from the eye. It is important to stress that in all dislocations the vitreous, in its hyaloid membrane, is made to press forward and thus rupture the attachment of the lens to the suspensory ligament.

Verhoeff,<sup>23</sup> in 1927, published the following ingenious method of intracapsular cataract extraction. After the section, external pressure on the lens was made below, thus causing the head of the lens to tilt forward, and the capsule was grasped at its upper equator. The lens was straddled on its anterior and posterior surfaces with a special forceps, shaped like a ring. To do this, the anterior zonular fibers must be ruptured. The lens was then rotated from side to side and the remainder of the capsular attachment ruptured. Moderate pressure was exerted at the lower limbus below with a special ring-shaped expressor<sup>24</sup> while maintaining the grip with the forceps, and the cataract in its capsule was then slowly extracted head first. The anterior displacement of the cataract and the grasping of the capsule were facilitated when an iridectomy or a meridional iridotomy was practiced.

In the Verhoeff operation the grasping of the upper margin of the cataract was easiest in the immature cataract. The capsule ruptured most frequently at time of delivery, then, after the usual extraction of the nucleus and cortex, the capsule was separately seized and extracted. During extraction the lens must be pressed against the posterior margin

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22 Mendoza, R. Die Kataraktextraktion in der Kapsel nach Elschnig, Zentralbl. f. d. ges. Ophth. **27** 169, 1933, La extracción de la catarata en su cápsula, según Elschnig, Arch. de oftal. hispano-am. **32**:85, 1932.

23 Verhoeff, F. H. New Operation for Removing Cataracts with Their Capsules. Tr. Am. Ophth. Soc. **25** 54, 1927.

24 Verhoeff, F. H. Lens Expressor, Tr. Am. Ophth. Soc. **28** 305, 1930.

of the incision to hold the vitreous back and to avoid its loss. The dislocation is effected principally by traction and by moving the forceps from side to side, but counterpressure is important, as without it the capsule is apt to rupture.

Lindner<sup>25</sup> followed Verhoeff's procedure, and, after exposing the upper equator of the lens and grasping it with the Verhoeff forceps, extracted the lens with traction and counterpressure. This author used a modified Suarez-Mendoza suture and a peripheral iridectomy.

Kirby<sup>26</sup> attempted a preliminary dislocation below, according to Smith's method, the cornea was then retracted with a suture to permit direct inspection, the capsule was grasped above, and extraction followed with pressure below, according to the Verhoeff method. Kirby also developed a method of direct rupture of the zonule by stripping it from its attachment to the capsule and used it when he found the zonule resistant.

Elschnig combined the procedure of forceps traction on the capsule after dislocation below and tumbling of the lens. With his many publications, he added greatly to the introduction of the intracapsular forceps operation. Elschnig's additions to the intracapsular operation consisted in a retrobulbar injection and a superior rectus suture. His forceps is a modified Kalt type, and he practices a buttonhole iridectomy.

In Arruga's<sup>27</sup> operation the capsule is grasped with his special forceps as low as possible, beneath the iris with an opening of 4 mm. Traction is exerted upward and laterally. The nearer the periphery of the lens the traction is made, the more likely will be the zonule to tear. Arruga uses a curved hook, but makes very little counterpressure, and uses the hook only to follow up the lens as he draws it out of the section. Immediately after the section and after two peripheral iridotomies, the suture is put in at 12 o'clock. At the conclusion of the operation, two additional sutures are placed, and the iris is replaced. Arruga claimed that he ruptured the capsule in only from 3 to 4 per cent of cases. He was able to remove lenses with his method in persons 30 years of age (zonular cataract). Loss of vitreous occurred in from 3 to 4 per cent of the cases.

Operators vary on the importance of traction with the forceps as compared with external pressure with the hook or other instrument in subluxating the lens. Smith stated the opinion that more reliance should be put on pressure with the lens hook and less on traction with the forceps. It is self evident that too much traction or too strong a grip

25 Lindner, K. Ueber Abänderungen der intrakapsularen Staroperation, *Ber u d Versamml d deutsch ophth Gesellsch* 52 392, 1938.

26 Kirby, D. B. Development of System of Intracapsular Extraction of Cataract, *Am J Ophth* 27 124, 1944.

27 Arruga, H. Les details techniques de l'extraction intracapsulaire du cristallin, *Bull et mem Soc franç d'opht* 46 270, 1933.

with the forceps ruptures the capsule, while vitreous prolapses more readily from pressure than from traction. The relation of traction to external pressure in the maneuver of subluxation has been expressed by several authors as follows. Davis employs 95 per cent pressure and 5 per cent pull, Gradle, 80 per cent pressure and 20 per cent pull, Gailey uses more pressure than pull, while Lagrange and Spaeth use only traction. Arruga depends principally on traction and uses the hook only to follow up the lens as it is drawn out of the section. Verhoeff subluxates by torsion and traction. In my opinion, the forceps should hold the cataract with gentle traction while the external pressure with the hook succeeds in effecting the subluxation, as traction is more likely to rupture the capsule than pressure.

It is essential to realize the importance of patience in this operation, since it is a procedure that takes much longer than the usual extracapsular operation. The subluxation must be done very slowly so as to allow the molding of the cataract, especially when operating with a round pupil, and the percentage of successful intracapsular subluxations, without rupture, will be greatly increased.

#### ACCESSORY STEPS

There are a number of accessory steps which, in the intracapsular operation especially, have added greatly to the facility and safety of the operation.

*Akinesia*—While akinesia is important in every form of cataract operation, it has demonstrated its worth particularly in the intracapsular procedure, as control of the eyelids is essential to the safety of the operation. Smith made an important contribution to the intracapsular technic by devising a method of retracting and controlling the lids with the aid of a specially trained assistant, which was described as follows. On completion of the section the speculum was removed, the upper lid was drawn forward from the eyeball with a large, blunt-tipped tenotomy hook, and with the fourth and fifth fingers of the same hand the eyebrow was pushed up, so that the orbicularis action was controlled. The lower lid was pulled down with the index finger of the other hand. This maneuver was then simplified with the use of the Fisher retractors.

A means of inducing temporary paralysis of the orbicularis muscle was devised several years ago by van Lint<sup>28</sup> and O'Brien<sup>29</sup>, this has led to the two methods which are now in general use. The first method consists in a submuscular injection of the eyelids with an anesthetic agent. It is not always possible to obtain a complete effect with this procedure, and the edema of the lids is apt to get in the way of the

28 van Lint. Astigmatisme post-opératoire dans l'extraction de la cataracte avec glissement de la conjonctive, *Ann d'ocul* **151** 418, 1914

29 O'Brien, C. S. Akinesia During Cataract Extraction, *Arch Ophth* **1** 447 (April) 1929

operator The blocking of the seventh nerve at the stylomastoid foramen (Wright,<sup>30</sup> Heuven and Campos) was an improvement but was not sufficiently simple for general adoption

O'Brien's method, which consists in a deep injection anterior to the condyloid process, has given good results when the technic was mastered and the procedure given time to act The effect of the O'Brien method is so complete that after the operation care must be taken to close the palpebral opening This form of akinesia should be used not only in cataract operations but in every procedure in which it is necessary to throw the circumorbital musculature out of action With the aid of these more perfect procedures of anesthesia, the speculum need not be removed after the completion of the section and, in the absence of complication, can be left in place until the end of the operation

In addition to the local anesthetic, a subconjunctival injection is desirable to anesthetize the iris This is best done under the superior rectus muscle, so as not to obstruct the area of section A retrobulbar injection is used by many surgeons to anesthetize the ciliary ganglion This increases the anesthesia of the eyeball and often weakens the action of the inferior rectus muscle, which is desirable, as the turning down of the eyeball during the intracapsular operation is not without danger The retrobulbar injection may cause a softening of the eyeball, which in the opinion of many surgeons is favorable, as it reduces the tendency to prolapse of the vitreous If this softening is extreme, however, the proper conduct of the operation may be interfered with, so it is best to give the injection just before the operation To avoid hemorrhage into the orbit, this injection should be made close to the eyeball, and not deep into the orbit

*Superior Rectus Suture*—Placing of such a suture is another step which is often of great help, as it is the only way to direct the eyeball downward without making the edges of the wound gape This device of Angelucci and Blaskovics was applied by Elschnig to the intracapsular operation It is self evident that the suture must go through the tendon, a long-toothed forceps is needed to do this, after a preliminary injection of an anesthetic into the muscle has been made, as this step is otherwise painful I have found that this suture, if attached to some fixed object, increases the intraocular pressure and may be in the way, so I prefer to leave the suture loose, ready to use when it is necessary to direct the eye down, as in threatened prolapse of the vitreous The insertion of the suture late in the operation is obviously difficult

*Iridectomy*—The question of iridectomy has been answered in a number of ways A complete iridectomy undoubtedly makes the grasping of the capsule with the forceps easier, and it also is the best pre-

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30 Wright, R E Akinesia During Extraction of Cataract Arch Ophth  
2 691 (Dec) 1929

ventive of prolapse of the iris, which in the intraocular operation is an especially unpleasant complication, in the presence of any complication during the operation the old rule of performing an iridectomy holds true. Aside from the resulting optical imperfection, with increase of glare, and the cosmetic objection, the greatest drawback of iridectomy in the intracapsular operation is that it allows the vitreous to come forward after the extraction of the lens, and this favors the vitreous becoming attached to the cornea or entangled in the incision, with consequent serious complications. Most of my intracapsular operations were done with complete iridectomy, though I realize now the correctness of the last-named objections.

*Buttonhole Iridectomy*—To obviate the loss of a round pupil in cataract surgery, Chandler, of Boston, in 1890, suggested a peripheral buttonhole iridectomy. This became known in European literature as the Pfluger-Hess procedure and is now used by many intracapsular operators. Some operators made from one to three peripheral openings in the iris. Peripheral iridectomy has greatly succeeded in preventing prolapse of the iris and preserves the optical advantages of the round pupil.

*Iridotomy*—The buttonhole iridectomy was replaced by some operators with iridotomy. This consists in making a small equatorial incision at the root of the iris with the ordinary fine-pointed or the de Wecker scissors. This step was especially advocated by Dimmer and was later adopted by Elschnig in his intracapsular technic. Some surgeons think that the resulting opening is not large enough to prevent prolapse. Its one objection is that it is not always easy to perform, and the possibility of cutting into the vitreous is always present. This injury to the vitreous may explain some of the complications which develop in otherwise uncomplicated extractions, such as low grade inflammatory reactions, of which the updrawn pupil is the most striking. The buttonhole iridectomy or iridotomy can be done before or after the extraction of the lens, this step is more easily and more safely performed before the extraction of the cataract, and with the tumbling maneuver the lens is not caught in the coloboma of the iris.

In addition to the administration of sedatives, these steps have greatly succeeded in making the operator independent of the patient's cooperation and have removed many of the dangers of the cataract operation.

*Corneal Sutures*—These were very slow in adoption. Elschnig,<sup>31</sup> speaking of wound sutures, commented on how slowly ophthalmic surgeons adopt advances in general surgery. Czermak,<sup>32</sup> in 1888, was

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31 Elschnig, A. Ueber die Naht bei der Altersstaroperation, *Klin Monatsbl f Augenh* 76 30, 1926.

32 Czermak, W. Ueber Extraction der Cataract ohne Iridectomie mit Naht der Wunde, *Wien klin Wchnschr* 1 592, 1888.

probably the first to pass a suture through the cornea and sclera on both sides of the center of the incision after making the section. He abandoned the method on account of infection and prolapse of the iris.

After a number of years, interest in suturing slowly developed, and the necessity of the sutures passing through the corneal and scleral tissues in order to obtain exact coaptation of the wound surfaces without overriding is now generally recognized. The sutures must not cause traction or deformity of the eyeball.

The methods of suture can now be divided into those in which the sutures are applied before and those in which they are applied after completion of the section. The first type apparently originated with Suarez de Mendoza,<sup>33</sup> who made an external incision in the cornea and then introduced a suture through both edges of the wound, subsequently completing the section in the line of the incision.

In 1894, Kalt<sup>34</sup> suggested a much simpler method by passing before the section a vertical suture through the superficial layers of the cornea 1 mm below the limbus and 3 mm above, horizontally through the episclera and conjunctiva, the section was then made between the sutures. In the method of Liégard,<sup>35</sup> at the beginning of the operation a parallel horizontal suture was passed at the upper corneal margin and through the conjunctiva and episclera above. Elschnig<sup>36</sup> used this method in cases of threatened loss of vitreous and of luxated cataract. Stallard<sup>37</sup> described a suture similar to Liégard's. Cornet<sup>38</sup> regarded an intra-capsular extraction without sutures as inconceivable and used the Gomez-Marquez suture, which is like Kalt's.

The suture methods applied after completion of the section are more or less the same. A simple and satisfactory method consists in passing the sutures through the conjunctival flap and the superficial layers of the cornea and of the sclera. These sutures are then returned through the conjunctival flap on emergence and, besides producing a firm closure of the wound, insure a conjunctival protection to the section. From one to six sutures are inserted, according to the views of the operator.

33 Suarez de Mendoza. La suture de la cornee dans l'operation de la cataracte, Arch d'opht 9 444, 1889

34 Kalt, E. On the Corneal Suture in Cataract Extraetion, translated by H Knapp, Arch Ophth 23 421, 1894, Bull Soc d'opht de Paris, 1894, p 118

35 Liégard, H. Une modification au procede de suture de la cornee dans l'operation de la cataracte, Ann d'ocul 149 119, 1915

36 Elschnig, A. Staroperation mit Naht, Klin Monatsbl f Augenh 75 775, 1925

37 Stallard, H B. Corneo-Scleral Suture in Cataract Extraetion Brit J Ophth 22 269, 1938

38 Cornet, E. D'une suture provisoire de securite pour l'extraction capsulo-lenticulaire de la cataracte, Ann d'ocul 175 322 1938

The study of suturing led to an improvement in needles, in the suture material and in the necessary instruments. Kalt and Barraquer introduced especially fine needles, which required a delicate needle holder. Automatic needles were then devised, making the procedure easier. A suitable fine forceps was desirable.

On the other hand, several voices were heard (that of Imre and others) which proclaimed that sutures were superfluous and troublesome and that their removal was not always simple.

Three methods of suturing are now in use in the United States and show that the preoperative method of suturing is at present the favorite.

Verhoeff<sup>39</sup> devised a tunneling suture, in which a scleral incision is made at the limbus after a conjunctival flap has been dissected down, two sutures are introduced, each making a track in the sclera. The incision is then made which cuts the sutures, and new sutures are then passed through the old tunnels. This technic undoubtedly succeeds in accurate coaptation but is complicated and prevents freedom in making the corneal section.

McLean,<sup>40</sup> after dissecting down a conjunctival flap of 5 mm, makes a tangential incision partially through the sclera at the limbus. Two sutures are passed through the conjunctival flap, reversed, they are passed through the sclera above and come out in the scleral stroma at the cut section. The sutures are continued through the corneal stroma and emerge just beyond the base of the conjunctival flap. The sutures are drawn to one side, and the usual section is made with a cataract knife in the line of the external incision. This insures that the section is always in the limbal plane and that the sutures go sufficiently deep into the sclerocorneal tissues. The sutures close the incision tightly, and the anterior chamber starts to reform very soon.

Bracken<sup>41</sup> uses a double-armed suture, which takes a horizontal bite of 4 mm in the cornea just below the limbus. After section, both terminal threaded needles are passed vertically through the deep episcleral tissue above the incision, at 11 and 1 o'clock, and the strands are loosely tied. After the delivery of the lens, the suture is immediately tightened, especially in the presence of any complication. Additional sclerocorneal sutures are passed at 10 and 2 o'clock. These sutures insure a quick reformation of the anterior chamber.

The suture applied before the incision renders the incision more difficult, freedom in making the section is interfered with, the iris is

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39 Verhoeff, F. H. Corneoconjunctival Suture for Cataract Operation, *Arch Ophth* **56** 137, 1927

40 McLean, J. M. New Corneoscleral Suture, *Arch Ophth* **23** 554 (March) 1940

41 Bracken, F. Complications Incident to Simple Intracapsular Extraction. Some Procedures Designed Toward Prevention, *Arch Ophth* **34** 427 (Nov-Dec) 1945



apt to fall before the knife, with the early escape of aqueous, and the necessary enlargement of the section with scissors is not desirable. Sutures can be readily applied after the section, but especially sharp needles and suitable instruments are essential. Whatever suture method is used, it is imperative that nothing be done to interfere with healing, namely, there must be no traction of the flap and no constriction of the tissues, in short, the suture must be accurately applied.

A final point on the subject of sutures is their occasional difficulty of removal, though frequently they fall out of themselves. Absorbable surgical gut sutures are now being used by some operators, but this substance seems to be more irritating than silk. Finally, it must be remembered that sutures are an additional test of asepsis.

An accurate and early closing of the incision is undoubtedly a great step in advance in the after-healing of the cataract operation. It prevents many of the complications that frequently impair the success of the cataract extraction, such as prolapse of the iris, which, though not entirely prevented, is greatly reduced, and hyphema is definitely less frequent. The advantages of the early reformation of the anterior chamber will be taken up later. The suture is also of value in presentation of vitreous and in this instance must be tied immediately.

To insure further early restoration of the anterior chamber, either a solution of sodium chloride or air can be injected into the chamber at the conclusion of the operation. This counteracts any tendency to anterior adhesion of the hyaloid membrane or of the iris. Some operators prefer the saline solution to air, since a much firmer closure of the wound is necessary to retain the solution.

## INSTRUMENTS

A number of suction apparatus have been devised, beginning with the first, by Hulen, Barraquer and Stoewer, simpler instruments were suggested by the Greens, Dimitry, Argañaraz, Rochon-Duvigneaud, Castroviejo and others, which avoided the complicated machinery and resulting difficulties of the pneumatic pump. They all succeeded in taking a grasp of the capsule in certain cataracts (intumescent and morgagnian) which offered difficulties for the forceps.

*Capsule Forceps*—The capsule forceps must grasp the capsule in all varieties of cataract and preserve a firm hold without tearing the capsule. The first forceps used for the intracapsular operation was the Manolescu model, which was constructed like the convex curve of a blunt-tipped iris forceps. In 1909 Kalt devised a forceps on the Terson model with a blunt, bifurcated tip for the extracapsular extraction, with the purpose of tearing out a large piece of the anterior capsule. I began to use this forceps, in 1910, in the intracapsular operation and continued to use it until the Ariaga forceps appeared, the Ariaga model

was better, as it did not tear the capsule so easily. The Kalt forceps soon became popular as the intracapsular operation was taken up more generally, and it was modified in many ways. Other capsule forceps carry the names of Elschmig, Green, Sinclair, Lagrange, Imrie, Blaskovics, Davis and Airuga.

The latest Airuga forceps has the following characteristics. The approximation of the two tips is perfect, and the pressure on closing the branches is uniform at all places, the margins neither cut nor are too round. The pressure up to the point of arrest is not strong enough to tear the capsule. The grooves on the internal surface of the branches are an important addition, as they aid in grasping a tense capsule, the tip is also more pointed, and the blades form a notch posteriorly, so they do not take hold of the capsule near the center of the lens, a technical point which usually interferes with the tumbling of the lens. The operator's fingers should be applied at the center of the forceps so as not to use too much force. Airuga claimed that if the forceps is in good condition and the technic is correctly followed, 90 per cent of the lenses should be subluxated.

It is well to remember that the forceps must take a firm hold at one point in order to concentrate traction on only a few of the meridional fibers. As soon as the initial tear has taken place, the separation of the remaining fibers is easily accomplished. The forceps must be small, as it has to find a place in the anterior chamber in addition to the tumbling lens if the operation is completed by traction. It has seemed to me, in the application of the forceps, that the broader the hold of the capsule and the larger the piece of the capsule seized, the greater the prospect of the forceps slipping. But if a smaller bite is taken on tilting the handle of the forceps forward, the capsule is more easily torn. When a broader grasp is taken, the upper meridian is more pulled on or distorted as the lens tumbles, and rupture of the capsule is more likely. A small bite concentrates on only a few meridional fibers but it has the great disadvantage that it tears the capsule if the capsule is a weak one.

Csillag<sup>42</sup> constructed a forceps that grasped the capsule in a horizontal fold, to avoid excess tension in the tumbling maneuver. Roth and Klein<sup>7</sup> expressed the belief that for the success of the intracapsular operation it is necessary that the capsule be grasped with the forceps and that the capsule be stronger than the zonule. These authors expressed the hope that when the ideal forceps is constructed the number of capsules which cannot be grasped will be reduced to a minimum. At the same time, the relation between the strength of the capsule and

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<sup>42</sup> Csillag. Querfalte fassende Starpinzette zur intrakapsularen Starextraktion durch Sturzen, Klin Monatsbl f Augenh. **93** 375, 1934.

the zonule remains an important factor. If the zonule is very resistant, danger to the ciliary body is avoided because the capsule ruptures. The thickness of the capsule is of great importance.

*Speculum*—This is an important instrument in the intracapsular operation. It must be light, it must protect the lashes, it must be easily removable with one hand. I have always used the model devised by Koster, late professor of ophthalmology in Leyden. This is a light and ingenious speculum made of piano wire. After the section, in the practice of many, the speculum is removed, and the lids are held apart by special retractors or by blunt hooks. With advances in akinesia, it is practical to retain the speculum in place throughout the operation. The Pretori speculum has been ingeniously modified by Blaskovics, Oláh<sup>43</sup> and Arruga. It is well adapted for the intracapsular operation, as it holds the eyelids away from the eyeball by supports, but the instrument is somewhat bulky and difficult to extract in an emergency.

It is not necessary to describe the course in the cases of intracapsular extraction. The freedom from reaction is well known, the eyes remain singularly white, and it is often unnecessary to instil atropine. Anything that interferes with the course of healing is usually a complication that has occurred during the operation, and this subject will be discussed in the following section on complications.

### COMPLICATIONS

The complications of the intracapsular operation are to a certain extent dependent on the improper selection of the cataract. There are several forms of cataract which lend themselves most readily to the intracapsular extraction. It is well to remember that with age the capsule thickens and the suspensory ligament atrophies. As a result, a dislocation of the cataract in the young is impracticable, and the determination of how much traction can be exerted without danger to the ciliary body is a matter for each operator's experience. Histologic changes have not been noted in the ciliary body on microscopic examination of eyes which have been operated on, though I have the distinct impression that cyclitis has resulted in some of my cases in which the subluxation was difficult.

The so-called intumescent cataract is an early cataract in which the cortex is swollen, the capsule is tense and offers the greatest difficulty to a satisfactory hold with the blunt forceps. The forceps slips off, and if a grasp succeeds in holding, the thin capsule frequently ruptures. The seizure can be facilitated by tilting the handle of the forceps forward so that more of the points of the blades is engaged and a smaller

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<sup>43</sup> Oláh, E. Technique of Preparing for Cataract Operation, *Am J Ophth* 15 626, 1932.

area of the capsule is seized, though this increases the likelihood of capsular rupture.

It is with cataracts of this type that the suction procedure is helpful. The rupture of the capsule results in conditions found in the extracapsular operation and becomes complicated if prolapse of the vitreous is present. The sclerosed, or amber-colored, cataract usually offers few difficulties, while the very frequent nuclear and posterior cortical cataracts are the most favorable. The hypermature (moigagnian) cataract is often difficult to grasp, and the shrunken disciform variety offers little resistance to the vis a tergo of the vitreous and is difficult to extract in the capsule.

In performing the intracapsular procedure, attempts at subluxation should be kept within reasonable limits. If, on varying the direction of traction and counterpressure, no result is obtained after a certain time, it is well to desist and to change to the toothed forceps. With cataract in the immature stage it is always best to wait until the anterior chamber is sufficiently deep to permit an adequate section, as there is nothing more important in cataract surgery, especially in the intracapsular extraction.

*Loss of Vitreous*—This is the most important complication. Much has been written minimizing loss of vitreous in the intracapsular operation, but it cannot be sufficiently stressed that any disturbance of vitreous is serious and should be avoided. It is not the amount that is so important, it is the presence of the hyaloid membrane in the incision, which interferes with the normal healing of the incision and leads to inflammatory changes in the eyeball. The more experience one gathers in cataract surgery, the greater respect one acquires for the vitreous. The changes which the vitreous undergoes with age and as a part of the cataractous process may be a factor in prolapse of the vitreous.

It is an old clinical observation that loss of fluid vitreous is the less serious complication, though its amount cannot be controlled and the immediate closure of the wound with a tight suture is essential. In cases in which the loss has been great and the eyeball has collapsed the injection of saline solution has been practiced, by filling out the eyeball, this facilitates the coaptation of the wound edges. The loss of vitreous does not lead to detachment of the retina, but the ensuing inflammatory changes in the vitreous may form adhesions to the retina which, in pulling on the retina, detach it. The occurrence of loss of vitreous in the intracapsular cataract extraction has unquestionably been reduced by advances which have been made in the accessory steps of the operation. The immediate tying of the sclerocorneal sutures, in the opinion of many, is also of great benefit if the vitreous presents or is lost during the operation. At the same time, the presence of sutures

may interfere with a clean excision of the prolapsed portion of the vitreous

The importance of loss of vitreous during the cataract operation depends greatly on the stage of the operation in which the loss takes place. In the intracapsular forceps operation loss of vitreous generally occurs after the cataract has been extracted, and prolapse in this terminal stage does not require the introduction of an instrument into the eyeball, and the resulting inflammatory changes are minimized. Prolapse occurring during the operation or before the delivery of the cataract requires particular measures, which will be described in the next paragraph. In any case, the incision must be freed of vitreous, so that the edges of the wound can close accurately, as a firm cicatrix is necessary to prevent late infection.

In my analysis of 500 successive cases<sup>44</sup> I find 42 cases of loss of vitreous. These cases occurred as follows: In the first hundred cases, 16, in the second hundred, 9, in the third hundred, 7, in the fourth hundred, 5, and in the fifth hundred, 5.

The incidence of loss of vitreous given in reports of Elschnig, Verhoeff, Arruga, Davis and others is about 5 per cent. The improvement in my series can be explained by better anesthesia and better technic.

In considering prolapse of vitreous, it is important to note in what stage of the operation the loss of vitreous occurred. Thus, in my series the loss occurred (1) directly after section in 5 cases, (2) during subluxation of the cataract in 12 cases, (3) after delivery of the cataract in 12 cases and (4) at the end of the operation in 12 cases.

Prolapse occurring directly after incision (stage 1) was usually due to a dislocated lens, and vitreous appeared in the anterior chamber during the incision. This complication occurs as well in any type of extraction of cataract and so can be dismissed from this consideration. Vitreous was lost about equally in each of the other stages. Prolapse during subluxation (stage 2) occurred when the capsule forceps dislocated the lens and ruptured the hyaloid membrane at the same time.

The rupture of the hyaloid membrane may take place in any part of the circumference, this was noted by the appearance of a black gap between the pupillary margin and the cataract and by the deepening of the anterior chamber. When this occurs, the speculum should be replaced with retractors, the capsule of the cataract should be grasped again with the blunt forceps, if it has been released, and the dislocation completed below and the lens extracted, a procedure which often succeeds without additional loss of vitreous, or, if the capsule cannot be grasped, loop extraction is performed. The rupture of the hyaloid mem-

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<sup>44</sup> Knapp, A. Complications of the Forceps Intracapsular Cataract Operation Based on an Analysis of Five Hundred Successive Cases, *Arch. Ophth.* **16** 770 (Nov.) 1936.

brane may be due to the application of too much traction with the forceps, to an adhesion of the capsule to the hyaloid membrane or to an unexpected movement of the patient

In prolapse after delivery of the lens (stage 3 of the operation) the vitreous directly followed the lens as if it was adherent to it or because too much pressure was applied. In the final stage (stage 4) the loss of vitreous occurred in the process of replacing the iris or of adjusting the conjunctival flap or on removing the speculum. The relatively large number of cases of loss of vitreous in the last stage of the operation was probably due to the fact that after extraction the vitreous body was deformed, extended forward and was thereby readily injured by the spatula.

Final vision in the cases with loss of vitreous in this series was as follows: 20/20 in 6 cases, 20/30 in 17 cases, 20/40 in 5 cases, 20/50 in 2 cases, 20/60 in 2 cases, 20/70 in 6 cases, 5/200 in 2 cases, perception of hand movements in 1 case and perception of light in 1 case. The poor visual results were due in part to maculae corneae in 2 cases (vision of 20/70), to central choroidal changes in 2 cases (vision of 5/200), to partial subchoroidal hemorrhage in 1 case (vision of 5/200), to atrophy of the optic nerve in 1 case (perception of hand movements) and to retinal detachment in 1 case (perception of light).

Fortunately, in this type of intracapsular operation the amount of vitreous lost was small, the loss generally occurred after the delivery of the lens, so that no instrument was introduced into the eye and no trauma was done to the body of the vitreous, with resulting opacities and organizing bands. The fear that detachment of the retina may follow loss of vitreous is not justified, the small amount of vitreous lost cannot be a factor unless opacities of the vitreous or other inflammatory reactions follow and cause changes in the structure of the vitreous which lead to detachment. This phase will be taken up in the consideration of retinal detachment.

The loss of vitreous in the intracapsular operation is often followed by a characteristic deformity, i. e., an updrawn pupil. In fact, even when no vitreous is lost, the pupil may be distorted if in the cases of iridectomy care has not been taken to replace the iris pillars carefully. The reason for the updrawn pupil is not always clear, but it can be assumed that an injury to the vitreous has occurred, which has led to a cicatricial contraction of the vitreous and the adherent iris. This may reach such an extent that the pupillary opening is obliterated and an iridotomy is necessary. Distortion of the pupil, according to Vannas, is caused by entanglement of vitreous in the incision or entanglement of threads of a persistent pupillary membrane. Kubie blamed it on traction of the zonular fibers in instances of disturbance of the vitreous. The incarcerated vitreous undergoes fibrous degeneration and shrinks (von Sallmann).

Another complication is rupture of the capsule during the extraction of the cataract. Its severity depends on whether the hyaloid membrane is also ruptured and in what stage of the extraction the rupture occurs. If rupture takes place before delivery of the cataract, the capsule has to be kept hold of, or another grasp must be taken. If the rupture takes place in the terminal stage, the capsule usually can be easily extracted after delivery of the cataract. In my series this rupture occurred in 20 cases, the capsule was subsequently extracted in 18 cases with satisfactory visual results. When the capsule cannot be grasped and extracted, its retention need not be troublesome if the pupil is fixed and the capsule is not adherent to the section.

*Iridocyclitis*—After the intracapsular operation mild inflammatory reactions are often due to slight trauma to the ciliary body or to the vitreous body. The bulging vitreous in the pupillary area will be found studded with pigment granules. Opacification of a protruding vitreous tissue, such as occurs after dissection of the after-cataract in the extracapsular operation, is unusual.

The complication of iridocyclitis was observed in 33 of this series of 500 cases. Iridocyclitis occurred in the cases of intracapsular extraction just as in the cases of extracapsular extraction, but much less frequently in the former, as the infection aggravated by the cortical remnants and the capsular tags, which are responsible for many complications in the latter operation, is absent.

In my series I noted that there were cases of mild iridocyclitis, moderately severe iridocyclitis with synechia, updrawn pupil and thickened hyaloid membrane, and, finally, a severe form. It is well known that after an intracapsular operation the pupil is easily dilatable, cortical remnants and inflammatory thickening of the capsule are absent, and posterior synechia and opacity of the hyaloid membrane rarely develop. All the patients with the mild form recovered with good vision. The patients with moderately severe involvement had posterior adhesions and a thickened hyaloid membrane, resultant vision was fair, dissection or iridotomy was rarely necessary.

The severe form occurred in patients with poor general health and was observed in 5 persons. It is characterized by the nonreformation of the anterior chamber and by the development of a persisting opacity in the deeper layers of the cornea and is accompanied with congestion and tearing. This is followed by deep vascularization of the cornea, all the symptoms of severe iridocyclitis, and, later, glaucoma.

This serious condition, I feared, was due to exertion of too great traction on the ciliary body when the subluxation was more difficult than usual. While this may be partly true, a better explanation may be found in a condition with which ophthalmologists have become more familiar in recent years, namely, a downgrowth of epithelium into the anterior chamber.

This most interesting and serious complication of intraocular surgery requires further study, and, as its treatment is unsatisfactory, additional care must be taken at the close of the operation to attain early firm union of the sclerocorneal section

*Glaucoma*—The infrequency of this complication following intracapsular operation is readily explained by the absence of anterior adhesions of the capsule to the incision, which is the usual cause of secondary glaucoma in aphakic eyes, though exceptionally glaucoma may follow an anterior adhesion of the hyaloid membrane to the posterior surface of the cornea or to the incision. It is interesting to note that in cases in which a cataract developed in a glaucomatous eye and an intracapsular operation was attempted the suspensory ligament was found to be brittle, so that the subluxation of the lens readily occurred, and after removal of the cataract in its capsule the ocular tension frequently remained reduced

Trauma to the corneal endothelium with the capsule forceps may cause the hyaloid membrane or the iris to become adherent before the anterior chamber is established, particularly in the tumbling maneuver, and glaucoma may result. This form of glaucoma is always a difficult complication to deal with, that the section was too small is probably a factor in its development. Another type of glaucoma occurs when the vitreous becomes adherent to the line of incision, and it is usually associated with adhesion of the iris and may also be due to an especially slow reformation of the anterior chamber. Arruga stated the belief that glaucoma is due to the vitreous obliterating the angle of the iris and agreed with me that a peripheral adhesion of the iris may result from nonreformation of the anterior chamber and thus cause glaucoma.

This is another reason for accurate suturing of the corneal incision and the prompt restoration of the anterior chamber. It is probable that the injection of air, or saline solution, into the anterior chamber at the close of the operation will help to prevent an anterior adhesion of the vitreous body, and in a secondary operation will help to prevent its reattachment (Hughes and Cole <sup>45</sup>)

Sugar <sup>46</sup> observed, on gonioscopic examination in 8 cases of glaucoma following the intracapsular extraction, that the angle of the anterior chamber was obliterated, just as in the cases of extracapsular extraction, and there was a similar delay in the reformation of the anterior chamber.

Glaucoma was observed in my series in 12 cases. In 3 cases it appeared at some time after the operation. In 9 cases it had been

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<sup>45</sup> Hughes, W. L., and Cole, J. G. Technical Uses of Air in Ophthalmology, Arch Ophth **35** 525 (May) 1946

<sup>46</sup> Sugar, H. S. Gonioscopy and Glaucoma, Arch Ophth **25** 674 (April) 1941



present before the cataract and was relieved by the cataract operation in 6 cases, and in 3 cases the glaucomatous condition persisted after the cataract operation and had to be treated by instillation of drops or operation

The intracapsular extraction has taught the value of the prompt restoration of the anterior chamber. This prompt restoration can be accomplished only by a clean section, which is free from entanglements, and by a firm union of the scleral and corneal surfaces of the wound with the aid of proper sutures.

*Detachment of the Retina*—The relative frequency of detachment of the retina after extracapsular and intracapsular operations has been a source of controversy. I am convinced that this complication is less frequent after the intracapsular operation, a belief which is borne out by a consideration of the causes of detachment. Organization of vitreous bands does not follow the intracapsular operation, as it sometimes does after discission, this is probably explained by the relative absence of inflammatory reactions in cases of intracapsular operation. Formation of holes in the retina from vascular disturbance occurs in patients who have been operated on for cataract, just as it occurs in any old person.

Retinal detachment is a complication which is often attributed to loss of vitreous during the intracapsular operation. In my series of 500 successive cases retinal detachment occurred in 6<sup>47</sup>. In 1 of these cases there was slight loss of vitreous at the time of operation. The amount was small, and, in my opinion, unless this increased the opacities in the vitreous it could not have been a factor. Vision at first was 20/30, and the detachment occurred two months after operation. Of the other cases, the period from the operation to the onset of the detachment was one year in 1 case, one and one-half years in 3 cases and two years in 1 case. The condition present in all the cases was opacities of the vitreous, and I believe that the opacities, indicative of low grade cyclitis, were responsible for the detachment.

Arruga expressed the belief that detachment occurs more frequently after the intracapsular operation than after the extracapsular operation, though I believe that he qualified this statement with respect to "myopic eyes." I am not prepared to share this view, particularly since detachment of the retina after the extracapsular operation is explained by injury to the vitreous, such as happens after too deep a discission, which forms organized bands and adhesions between the vitreous and the retina and leads to retinal detachment. This condition does not exist in the intracapsular operation, no inflammatory changes occur in the vitreous after this operation unless vitreous is lost or cyclitis develops.

In considering the relation of loss of vitreous to retinal detachment, the amount of vitreous lost is an important factor, as well as the length

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47 Knapp,<sup>44</sup> p. 774

of time after operation that the detachment occurred. It is conceivable that a large amount of vitreous lost at operation might be a factor in causing detachment which occurred a short time after, but in 5 of the 6 cases of detachment there was no loss of vitreous at operation and the detachment followed from one to two years after operation.

Arruga (in a personal communication) suggests that the vitreous body when it no longer is held back by the zonulocapsular septum extends forward and becomes more movable and that thereby traction on the periphery of the retina easily follows with formation of holes and detachment.

*Changes in the Hyaloid Membrane*—A peculiarity of the healing after the intracapsular operation is the persistence of blood on the hyaloid membrane in its natural color for months, frequently causing serious interference with vision.

A picture that resembles a secondary cataract consists in thickening of the hyaloid membrane, with resulting interference with sight. This is an unusual sequel and may require a cautious discussion after a sufficient length of time has elapsed.

#### COMMENT

The amount of literature that has arisen on the subject of the intracapsular extraction is bewildering, but some general direction can be recognized. The trend seems to be in favor of an operation in which a firm hold is taken of the capsule with the forceps without tearing it, concentrating the traction to one area and with a hook or similar instrument exerting pressure externally at the lower corneal margin, in order to raise the vitreous pressure and to rupture the suspensory ligament at that point. Smith thinks that the vis a tergo pressure of the vitreous, and not direct trauma to the zonule with the hook, explains the rupture of the zonule.

After subluxation of the cataract, the extraction is completed with the aid of external pressure, by tumbling or by head-first delivery. Many operators maintain the hold on the capsule throughout the operation, but in my experience release of the forceps after subluxation of the cataract reduces the number of ruptured capsules. The tumbling maneuver is favored except in the Verhoeff method. In general, more reliance should be put on pressure with the lens hook and less on traction with the forceps, but the operator must vary between traction and pressure according to the conditions present, and the best method depends on a delicate adjustment of these two procedures.

Preservation of a round pupil is desirable, as the iris tissue acts as a support for the vitreous body. Firm closure of the section by deep sclerocorneal sutures insures prompt restoration of the anterior chamber. Though the forceps method of intracapsular extraction is steadily

gaining in popularity, attempts should be made to correct the difficulty in grasping some cataracts with forceps by improvement in technic and in instruments. At present the Barraquer method is the most appropriate for the intumescent cataract.

#### ADVANTAGES AND DISADVANTAGES OF THE INTRACAPSULAR EXTRACTION

The chief advantage of the intracapsular cataract extraction is that the operation is practicable in the immature stage of the cataract. Furthermore, the visual results are surely much better than after capsulotomy. There are not many systematic reports on successive cases to furnish a comparison with the results previously obtained with the extracapsular methods. In my series of 500 successive cases, the visual results were 20/30 or better in 90 per cent, whereas the figures for this visual acuity in the cases of extracapsular extraction ranged from 52 to 62 per cent.

The after-treatment is simpler and shorter, and no after-cataract operation is necessary. The freedom from inflammatory reaction is striking and leaves no doubt about the role of retained cortex and capsule in promoting an infection. The iridocyclitis after the extracapsular operation, the difficulties that arise in correcting the subsequent visual disturbances and the secondary glaucoma are as trying as any complications that the ophthalmic surgeon encounters.

The disadvantages of the intracapsular operation are that the operation is more difficult and that there is greater frequency of loss of vitreous. Granted the greater difficulties, there is no reason that the technic of the operation should not belong to every competent ophthalmic surgeon.

De Saint Martin<sup>48</sup> found that conditions most suitable for intracapsular extraction are the immature nuclear or cortical cataract, phacoscclerosis and the mature cataract. Less suitable are the intumescent cataract in which the capsule is tense and slippery, the hypermature cataract, the cataract with large nucleus and fragile capsule, the shrunken cataract and the cataract associated with tetany.

Smith<sup>49</sup> stated that the intracapsular extraction is a difficult operation and capsulotomy is relatively easy and simple but that in skilled hands escape of vitreous is about the same in the two procedures. I cannot agree with this statement, as loss of vitreous in capsulotomy should be practically nil, while the best statistics on intracapsular cataract extraction give a loss in about 5 per cent.

Smith insisted on making a large enough section, even one of 190 degrees. Many operators fear a large section, not realizing that a small section means more pressure to dislocate the lens. Smith stated that if

48 de Saint-Martin, R. L'extraction capsulo-lenticulaire de la cataracte, Bull. et mem. Soc. franç. d'opht. de Paris 46: 387, 1933.

49 Smith, H. Treatment of Cataract, Arch. Ophth. 50: 515, 1921.

the forceps technic is employed the hold with the forceps must be very delicate lest it rupture the capsule and that most of the work should be done with the hook. He suggested that if one feels for the corneoscleral ring with the hook and pulls toward the patient's feet, the lens will always roll forward. Hard cataracts are likely to burst on application of the forceps.

Elschnig,<sup>50</sup> on reviewing his results with the various intracapsular methods, came to the following conclusions. He abandoned the Smith operation because an iridectomy was always necessary and the loss of vitreous was too great. The Barraquer method was too difficult and caused too much loss of vitreous. He was pleased with the forceps operation and recommended it for general adoption. This maneuver succeeded in 80 per cent of cases, in 10 per cent the capsule ruptured, and in 10 per cent the forceps did not take hold. Of 468 cases from his clinic,<sup>51</sup> loss of vitreous occurred in 25. The capsule ruptured in 23 cases. In 40 cases the pupil was drawn upward, glaucoma was observed in 5 cases, and detachment occurred in 2 cases. Elschnig did not regard exophthalmos or myopia as contraindications, though in his opinion the intumescent and adolescent cataracts were not suited.

Blaskovics<sup>52</sup> expressed preference for the tumbling method. With this technic, the maturity of the cataract no longer needed to be considered. Bilateral operation was of great advantage for some patients and should not be discarded.

Wright<sup>53</sup> said that the fact that ophthalmic surgeons fall back on capsulotomy when things are not quite right shows that they regard it as a safer procedure. In his experience capsulotomy was freer from complications, especially in the postoperative period. He used the forceps in the intracapsular extraction and favored the tumbling maneuver, for morgagnian and intumescent cataracts he considered phacoeresis (Barraquer) preferable.

Kadlichy<sup>54</sup> found that one cannot predict the success of an intracapsular extraction from the appearance of the cataract. In a series of 200 cases, the operation succeeded with only 33 per cent of the hypermature cataracts and with 32 per cent of the intumescent cataracts.

50 Elschnig, A. Altersstarextraktion in der Kapsel, *Ztschr f Augenh* **75** 1, 1931.

51 Kubik. Ueber die intrakapsulare Starextraktion nach Stanculeanu-Torok, *Klin Monatsbl f Augenh* **82** 592, 1929.

52 Blaskovics. Fortschritte auf dem Gebiete der Staroperation und Aenderung der Indikationen, *Orvosképzés* **26** 22, 1936, *Zentralbl f d ges Ophth* **37** 58, 1936.

53 Wright, R. Lectures on Cataract, *Am J Ophth* **20** 5, 1937.

54 Kadlichy, R. Kann man aus dem Aussehen der Katarakte die Möglichkeit der intrakapsularen Extraktion erkennen *Ceskoslov oftal* **2** 225, 1935. *Zentralbl f d ges Ophth* **36** 614, 1936.

In general, the intracapsular method succeeded in 73 per cent, and the extracapsular method was practiced in 23 per cent. The capsule could not be grasped in 15 per cent of cases, and it ruptured in 12 per cent. Vitreous prolapsed in 3 per cent.

In addition to the cataracts that Smith<sup>49</sup> laid down as unsuitable for intracapsular extraction, such as congenital cataract and juvenile cataract in persons up to 30 years of age, Holland<sup>55</sup> mentioned the large, prominent "on-eye" cataracts in full-blooded, plethoric, fat persons, cataracts in apparently normal persons that resist legitimate pressure, cataracts in persons between 35 and 50 years of age in which the zonule has proved too resistant, cataract associated with glaucoma, glaucomatous cataract and traumatic cataracts. Such cataracts did not amount to 5 per cent of all types.

According to Kugelberg, the advantages of the intracapsular extraction were a black pupil, free from cortex or capsule, a short convalescence, no inflammatory reaction and no secondary operation, while the only disadvantage was danger of loss of vitreous. He stated that the forceps extraction was the best method for the intracapsular method. In his experience, the technic of intracapsular extraction was more difficult, but the visual results were better and the percentage of loss of vitreous was small. In cases of incipient and immature cataract, the cataract was firm and easily grasped and the lens had a good form, facilitating the tumbling and final extraction of the lens. In youth the zonule was firm, in hypermature and in tremulous and morgagnian cataracts the zonule tore easily and the lens might slip into the vitreous. In intumescent cataract the capsule tore easily. The hard and pigmented cataracts were not suited, while cataracts associated with myopia, diabetes and heterochromic cyclitis and the nuclear cataracts of glaucoma were all favorable.

In Barraquer's<sup>14a</sup> opinion, intracapsular extraction by external pressure (Indian method) caused rupture of the hyaloid membrane, prolapse of the vitreous, impaction or loss of vitreous with late complications and iridocyclitis from lesions of the ciliary body and keratitis. The forceps operation succeeded (1) when the cataract was soft and deformable, so that a fold in the capsule could be made, (2) when the capsule was tough enough to resist traction at the place of the fold, and (3) when the zonular fibers had lost their elasticity and permitted tearing at their insertion on the crystalline lens on gentle traction. If these three conditions were not fulfilled, (1) the capsule could not

55 Holland, H. T. Some Contraindications to the Intra-Capsular Operation for Cataract Based on 8,000 Cases of Intra-Capsular Operation. *Indian M. Gaz.* 57: 296, 1922.

56 Kugelberg, F. Staroperation in der Kapsel, *Zentralbl. f. d. ges. Ophth.* 26: 564, 1932, Extraction of Cataract in Capsule. *Hygiea* 93: 689, 1931.

be grasped and there was danger of luxation, (2) a capsulotomy had to be performed and (3) the ciliary region was traumatized and the vitreous was deformed

According to Barraquer, the poor results obtained by some operators with the suction method were due to incorrect technic and to an imperfect apparatus. Phacoeresis avoided the complications of the forceps operation, such as rupture of the capsule, prolapse of vitreous and secondary reactions. To get the best results with the suction method, three conditions must be met. The suction cup must be of suitable size, there must be correct dislocation of the lens into the anterior chamber by disarticulation from the hyaloid fossa, without injury to vitreous and to the pupil, and, finally, the cataract must be extracted from the anterior chamber with the aid of the suction cup or by pressure on the cornea.

Complications listed against the Barraquer operation were opacities in the vitreous, detachment of the retina and late hemorrhages. These were due to rupture of the hyaloid membrane or to impaction, i. e., faulty technic. Late iridocyclitis was due to traction on the ciliary region (incorrect management of the vacuum). Hyphema and hernia of the vitreous in the pupil have disappeared since Barraquer began, in 1936, to use the present sclerocorneal suture, these accidents resulted from minute openings in the deeper layers of the incision, with escape of aqueous under the conjunctival flap.

Arruga said that the eresiphake is a very delicate instrument, like any pneumatic apparatus, and that traction on the zonule cannot be limited. The forceps was not suitable in cases of swollen cataract. The capsule should be grasped in the peripheral part, so as to limit traction to a very small sector of the zonule. In extraction with the forceps, Arruga depended mostly on traction, and in his experience damage to the ciliary body from traction was unusual. When the forceps did not take hold, he used the suction pump.

I have avoided head-first extraction and have found that two main problems might present themselves in the intracapsular operation: inability to grasp the capsule and rupture of the capsule. These problems should be solved with better forceps and with improved technic. The cataract was operable<sup>57</sup> as soon as the anterior chamber was deep enough to permit a satisfactory section and as soon as the patient was prevented from doing his work. The elasticity of the zonule and the thickness of the capsule could not be predicted, except by the age of the patient. Contraindications were the intumescent and morgagnian varieties. Tumbling was the safest procedure, if the lens was not readily subluxated, an extracapsular operation was resorted to.

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<sup>57</sup> Knapp, A. Certain Aspects of the Intracapsular Extraction of Cataract by Forceps, *Arch. Ophthalm.* **16** 419 (Sept.) 1936.

Amsler<sup>58</sup> correctly stated that the intracapsular extraction had great social advantages, as it extended the indications for operation, healing was more rapid and there was no after-cataract, but that the operation was more difficult. The dangers were greatly lessened by improved technic, such as akinesia. Luxation failed in 20 per cent of his series. In cases of senility, dementia and complete mature cataract the author preferred the extracapsular operation.

Degrazia<sup>59</sup> found two main objections to the forceps operation (1) frequent rupture of the capsule and (2) slipping of the forceps when the capsule was tense and smooth. Though in Barraquer's operation there were fewer ruptures and it was applicable to more types of cataract, greater delicacy was necessary and loss of vitreous was greater. In the forceps operation the technic was easier, there was less loss of vitreous but a great number of capsules ruptured and there was a large number of unsuitable cases. With both methods the post-operative convalescence was simple with the same excellent visual results and a minimum of inflammatory reaction.

Degrazia expressed the opinion that in the forceps operation tearing of the zonular fibers occurred at the insertion in the ciliary body and frequently caused iridocyclitis. On the other hand, in the suction method the zonular fibers were torn at their capsular attachment.

Poyales<sup>60</sup> rejected the Smith method and found the drawback to Barraquer's procedure to be the difficulty of exactly gaging the vacuum, which made the action of the pump uncertain. The forceps method was good when the resistance of the capsule was stronger than that of the zonule.

Meller<sup>61</sup> described the various complications of the intracapsular operation and stated his opinion that it was indicated only in a carefully selected group of cases. Without underestimating the undoubted advantage of the successful intracapsular operation, he said that he hesitated to replace a perfectly safe procedure with a definitely more risky operation.

Kirkpatrick recognized the advantages of intracapsular extraction but concluded that the operative risks and complications did not justify its adoption, except in a few selected cases principally on account of loss of vitreous.

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58 Amsler, M. De quelques operations oculaires, *Schweiz med Wchnschr* 66 1268, 1936.

59 Degrazia, N. C. Ueber die Staroperation, *Arch clin oftal* 6 78 1939. *Zentralbl f d ges Opth* 44 628, 1940.

60 Poyales, F. Die Totalextraktion der Katarakt, *Arch de oftal hispano-am* 28 327, 1928, *Zentralbl f d ges Opth* 20 488, 1929.

61 Meller, J. Ueber den Anteil der Wiener augenarztlichen Schule an der Entwicklung des Verfahrens, den grauen Star in der Kapsel auszuziehen, *Wien klin Wchnschr* 50 755, 1937.

Davis<sup>62</sup> preferred the combined extraction method and extracted the lens by tumbling in 92 per cent of his cases, in the rest he extracted the ruptured capsule separately. Rupture of the capsule was most common in cases of a completely sclerosed lens. He used a special forceps,<sup>63</sup> with which a large area of capsule was grasped. Loss of vitreous was 6 per cent. Hyphema occurred too frequently with any method of operation. In his opinion,<sup>64</sup> though the present trend was toward the intracapsular extraction with preservation of the round pupil, this operation was neither the easiest nor the safest method of extraction. Dunnington commented, in the discussion, that in operations with preservation of the round pupil the grip of the sphincter of the iris and the thin diaphragm of iris tissue were the retarding factors in prolapse of the vitreous, though the complications, when they did happen, were severe. The feature in favor of a complete iridectomy over the round pupil operation was the less frequent rupture of the capsule.

*Preservation of the Round Pupil*—The advantages of preservation of the round pupil are well known, though iridectomy may be advisable in cases of chronic iritis and of glaucoma, in cases in which the pupil does not dilate and prevents the passage of the lens and, finally, in cases in which cooperation in the after-treatment on the part of the patient cannot be depended on. The preservation of a round pupil prevents the presentation of vitreous after the extraction, though the vitreous becomes deformed from the reduction of the intraocular pressure. This prevention is brought about by the intact iris tissue and the grip of the pupillary sphincter, undoubtedly increased by the customary use of physostigmine at the conclusion of the operation. The beneficial effect of the preservation of a round pupil in reducing the incidence of loss of vitreous has been observed by a number of operators.

Hughes and Owens,<sup>65</sup> in a series of intracapsular extractions with corneoscleral suture, showed that the loss of vitreous was reduced from 14.5 and 12.7 per cent, in cases with iridectomy, to 2.7 per cent, in the cases in which the intracapsular extraction was done with round pupil. This striking reduction in loss of vitreous must also be attributed to improved technic. In Bracken's experience, the loss of vitreous was much reduced when operating with the round pupil, in at least three fourths of the cases.

62 Davis, F. A. Personal Experiences with Intra-Capsular Cataract Extractions, *Arch Ophth* **19** 867 (June) 1938.

63 Davis, F. A. Capsule Forceps for Intra-Capsular Cataract Extractions, *Tr Am Ophth Soc* **34** 239, 1936.

64 Davis, F. A., in discussion on Hughes and Owens,<sup>65</sup> p. 261.

65 Hughes, W. F., Jr., and Owens, W. C. Extraction of Senile Cataract, *Tr Am Acad Ophth* **49** 251, 1945.



*Sutures*—According to most operators, suturing has almost done away with prolapse of the iris, but opinions are not so uniform on the prevention of hyphema.

Leech and Sugar,<sup>66</sup> in comparing the results in cases in which deep sclerocorneal sutures were used with those in cases in which no sutures or only conjunctival sutures were used, concluded that in the former the number of cases of prolapse of the iris and of hyphema were reduced and the anterior chamber was reformed earlier. When prolapse of vitreous occurred during the operation, further loss was prevented by closing the wound securely after delivery of the lens. The patients were allowed up earlier and were given greater freedom, and restlessness was not so dangerous. The authors found most suitable the type of suture which was placed prior to making the corneal incision, and their suture is similar to the one described by Stallard. Barraquer also noted that his results were much improved after using corneoscleral sutures.

*Prompt Reformation of the Anterior Chamber*—It has been shown how important is the prompt restoration of the anterior chamber, in prevention of several serious complications, and how this can be much facilitated by proper suturing, which thus becomes an important step in the operation. Some operators even speak of a water-tight anterior chamber, and one beginning to reform before the end of the operation, others regularly find the chamber reformed on the following day. The injection of air, or saline solution, is an important adjunct.

The complications ascribed to the slow reformation or nonreformation of the anterior chamber are due to interference with the intraocular circulation, whereby anterior peripheral adhesions of the iris develop or the hyaloid membrane of the vitreous body becomes adherent to the corneal endothelium, and glaucoma results. Another, very serious, complication is the downgrowth of epithelium into the anterior chamber.

*Late Results*—It has been claimed that the intracapsular operation unduly traumatizes the eye, displaces the pupil and causes degenerative changes in the vitreous which damage the eye. To investigate these important claims, it seemed best to reexamine patients several years after operation. I was able to follow the course of 85 patients from ten to fifteen years after operation<sup>67</sup> and found that 16 patients who had died had retained good vision, as shown at the last examination or as reported by relatives. Fifty-seven patients were reexamined, and it was found that vision was as good as after the operation or that it had improved, 5 of these patients had had slight loss of vitreous.

<sup>66</sup> Leech, V. M., and Sugar, H. S. Reduction of Post-Operative Complications in Cataract Operations with Corneo-Scleral Sutures, *Arch. Ophth.* **21** 966 (June) 1939.

<sup>67</sup> Knapp, A. Late Results of Intracapsular Cataract Extraction, *Arch. Ophth.* **55** 257, 1926.

In these 57 patients, the cornea was perfectly clear, there was no updrawing of the pupil and the coloboma of the iris was regular except in a few with slight distortion of the pupil from posterior synechia or from anterior adhesion of one pillar, due to prolapse of the iris or loss of vitreous

The conditions for the examination of the vitreous in the cases of intracapsular operation were perfect, and the vitreous was found to be unusually clear. There is no question that the vitreous was much freer from opacities than in the cases of capsulotomy. This was to be expected from the greater freedom from iridocyclitis in the cases of intracapsular operation. In general, these late results showed that if the primary result was good excellent vision was retained, as found on reexamination ten or fifteen years after operation, there were no evidences of degeneration of the vitreous or of any other lesions, and the patients had surprisingly little trouble from their eyes.

*Baring of the Vitreous*—The intracapsular cataract extraction has given ophthalmologists an opportunity to study a new clinical picture, namely, the barring of the anterior surface of the vitreous body, not only in the pupillary area but in the ciliary region, and its behavior when exposed to the aqueous fluid. Many theoretic reasons have been advanced to describe the ill effects of this exposure of the vitreous, but, strange to say, such effects have not been observed clinically.

On examination in a case of intracapsular extraction, the pupillary area may be found to contain loose vitreous and the hyaloid membrane may not be identified, or there may be faint opacification of prolapsed vitreous tissue in the anterior chamber. The vitreous may protrude like a balloon and move freely. The hyaloid membrane may be definitely thinned but is thick enough to hold back the vitreous. This membrane is sometimes rather flat, or it may balloon forward on one side, where there is a synechia. Even when there is no hyaloid membrane, the vitreous sometimes bulges upward in the direction of the incision.

The bulging hyaloid membrane does not flatten out on dilation of the pupil. When the membrane is flat, there may be a number of round thin defects, like holes. The hyaloid membrane may be definite, herniated as a result of sphincter constriction and adherent to the pupillary border. In that case glaucoma may develop. Adhesion of hyaloid membrane to the section may cause glaucoma, a cicatricial transformation of the vitreous being present with distortion of the pupil. In cyclitic reactions particles of pigment are deposited on the bulging, cystic vitreous.

Excessive opacification of the vitreous prolapsed into the anterior chamber through gaps in the hyaloid membrane is sometimes observed. These masses are cloudy but do not interfere with the patient's vision and in the course of years undergo but very little change. These cloudy changes are well known in cases of capsulotomy in which the capsular

epithelium has been held responsible, an explanation which the present observation shows not to be tenable

Von Sallmann<sup>68</sup> in cases of choroidal detachment after intracapsular extraction, observed that the anterior part of the vitreous did not bulge forward but retracted posteriorly, forming a concave surface. In these cases the hyaloid membrane was situated behind the pupillary zone. This concavity was present only for a short time and might therefore escape detection.

Elschnig<sup>69</sup> said that after the intracapsular operation the vitreous formed a rounded, mushroom-shaped prominence which projected into the anterior chamber and was covered usually by a membrane riddled with many small holes. Free floccules of vitreous were often present in the anterior chamber, coming as far forward as the cornea.

After the intracapsular cataract extraction McDonald<sup>70</sup> found in 156 cases that a bulging vitreous flattened out and the hyaloid membrane did not thicken. If a tear developed, the vitreous extended forward to the cornea without damage. This observation was confirmed by others. The squeezing of the bulging vitreous by the contracted pupil might cause glaucoma. Changes in the iris or vitreous were not observed.

Carle,<sup>71</sup> in a review of cases four years after operation, found that vision had improved, with reduced astigmatism, and that the hernia of the vitreous into the anterior chamber had disappeared. No further displacement of the pupil had occurred, the vitreous and fundus presented no change.

Pereira<sup>72</sup> claimed that if the vitreous bulged into the anterior chamber, without coming in contact with the pupillary margin of the iris, no damage resulted, but that if the pupil contracted and constricted the vitreous glaucoma might result. If the pupil was very wide and the vitreous, for some reason, prolapsed into the anterior chamber, it might be caught like a mushroom and glaucoma develop.

Kwaskowski<sup>73</sup> found that when a hyaloid membrane was present a delicate light streak with pigment dots on the surface was detected.

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68 von Sallmann, L. Spaltlampenbeobachtungen an der vorderen Glaskörpergrenzhaut nach Entfernung der Linse in der Kapsel, *Arch f Ophth* **135** 602, 1936

69 Elschnig, A. Extraction of Senile Cataract in Capsule, *Am J Ophth* **8** 355, 1925

70 McDonald, R., in discussion on Appleman, L. Intracapsular Cataract Extraction, *Arch Ophth* **19** 548 (April) 1938

71 Carle, T. After-Examination of Patients Following Intracapsular Extraction of Cataract, *Acta ophth* **15** 516, 1937

72 Pereira, R. F. Glasskorpervorfall in die vordere Kammer und Glaukom nach intrakapsularer Starextraktion, *Arch de oftal de Buenos Aires* **2** 409, 1926  
*Zentralbl f d ges Ophth* **37** 498 1937

73 Kwaskowski. Die Glaskörpergrenzmembran nach der Staroperation, *Klin oczna* **17** 205, 1939, *Zentralbl f d ges Ophth* **44** 187, 1939

with the slit lamp. Occasionally the vitreous formed a hernia-like protrusion into the anterior chamber. This might be complicated by rupture of the hyaloid membrane, and then gelatinous masses with pigment dots on their surface might bulge into the anterior chamber. Threads might be connected with the incision and form adhesions. If iritis occurred, the hyaloid membrane became cloudy, with granular deposits, and many pigment dots were present.

Poyales and Moreno<sup>74</sup> said that if there was a rupture of the vitreous membrane (loss of vitreous) no partition between the anterior chamber and the vitreous space existed. Otherwise there was a curved protrusion of the intact membrane, or the membrane assumed a saclike deformation, with bulging below. A flat hyaloid membrane was unusual. Uniform bulging was ideal, and the authors found this condition most frequently in cases in which Barraquer's procedure was followed, while the most frequent destruction of the hyaloid membrane took place with the forceps extractions.

Vannas<sup>75</sup> could not decide whether the anterior membrane of the vitreous was a definite partition. In the presence of a rupture, vitreous substance bulged forward like a hernia. After the intracapsular extraction, the vitreous bulged forward into the anterior chamber whether the hyaloid membrane was intact or not. The author expressed the belief that a rupture might take place spontaneously some time after the operation. This late rupture has also been commented on by Woods and others. The hernia of the vitreous might vary in its degree of protrusion.

The fear of deterioration of the vitreous body, and, as a result, of the eyeball is based partly on the claim that the zonulocapsular diaphragm should be retained, as it is an important support for the internal structure of the eye. This is an important and interesting point. The retention of the vitreous body in its normal confines implies the desirability of uniform pressure on the retina, but clinical experience has failed to show any injury from the absence of this support.

Addario<sup>76</sup> expressed the belief that the integrity of the elastic zonulocapsular diaphragm must be preserved, hence, in his opinion all intracapsular operations were bad. The elasticity of the zonulocapsular system allowed it to exert pressure on the anterior segment of the vitreous body, so that the weight of the vitreous did not press on the ciliary processes and on the iris. It protected the ciliary processes when the

74 Poyales, F., and Moreno. *Morphologie de la membrane hyaloïde apres extraction totale de la cataracte*, Bull. et mém. Soc. franç. d'opht. **47** 211, 1934.

75 Vannas. *Klinische und experimentelle Untersuchungen über die vorderen Teile des Glaskörpers, insbesondere nach intrakapsularen Linsenextraktionen*, Klin. Monatsbl. f. Augenh. **89** 318, 1932.

76 Addario, C. *Il collapsus sclerae nell'operazione di cataratta*, Ann. di ottalm. e clin. ocul. **53** 900, 1925.

vitreous body was displaced during body movements. If the lens was completely removed, a broad communication existed between the vitreous and the anterior chamber, and the vitreous protruded into the anterior chamber. It seems to me that in this reasoning the retaining hyaloid membrane was overlooked.

Rochon-Duvigneaud objected to the intracapsular operation because of the exposure (baring) of vitreous and because prolapse of vitreous into the anterior chamber was not desirable. In his opinion, it was best to leave the posterior capsule as a protection for the vitreous.

According to Wright,<sup>77</sup> an eye with an intact zonulocapsular barrier was a better eye than one in which this barrier was not intact, he stated that the integrity of the vitreous must be preserved and that it was a better behaved vitreous when it was contained behind the zonulocapsular diaphragm.

### CONCLUSION

The visual results of the intracapsular operation are excellent and are better than those obtained in the extracapsular operation. The operability of the immature cataract is the most important advantage of the intracapsular operation. The remarkable freedom from reaction which follows this operation is one of its most striking features.

The intracapsular extraction is undoubtedly more difficult and requires experience to meet possible complications. It cannot be stated in advance that an intracapsular operation will succeed. The operation has been much simplified and made safer by advances in certain accessory steps, such as better anesthesia, wound suture and prompt reformation of the anterior chamber. The danger of loss of vitreous is undoubtedly greater, this loss is never to be minimized, and the correct treatment of this complication is always difficult. Rupture of the capsule is also a complication that may present difficulties, in brief, complications in the intracapsular operation are difficult to deal with.

The importance of the zonulocapsular barrier for the integrity of the eye is an unsettled question, and one that requires further study. The resulting displacement and the disturbed relationship of important structures in the interior of the eye suggest the possibility of damage to the eye, but late examination of many patients and clinical experience have not shown any evidence of deterioration of the eye from this cause.

The future of the operation lies in the reduction of the difficulties with improvement in the methods of operating and with better technique, when this has been accomplished, the statement of Herman Knapp, in a letter to Colonel Henry Smith in 1905, will hold true, namely, that "If you can establish a safe method of intracapsular cataract extraction, you will equal Daviel's contribution to humanity."

<sup>77</sup> Wright, R. Lectures on Cataract, *Am J Ophth* 20 1, 1937

# MYCOTIC OBSTRUCTION OF THE NASOLACRIMAL DUCT (CANDIDA ALBICANS)

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AND

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**M**YCOTIC infections of the lacrimal apparatus have been recognized since their description by von Graefe, in 1854. Numerous reports may be found in the literature of various fungi producing obstruction of the lacrimal passages. Streptothrix and leptothrix are mentioned in most textbooks as the organisms commonly encountered. In the great majority of cases the obstruction has consisted of mycotic concretions in the lacrimal canaliculi. Such cases have been reported, among others, by Fazakas,<sup>1</sup> de Saint-Martin,<sup>2</sup> Carsten,<sup>3</sup> Talice,<sup>4</sup> Elliott,<sup>5</sup> McClanahan,<sup>6</sup> Reese,<sup>7</sup> Valière-Vialeix<sup>8</sup> and Brinkerhoff.<sup>9</sup> Reports of mycotic obstruction of the nasolacrimal duct, however, are notably lacking.

Fazakas<sup>10</sup> made an intensive study of the mycotic flora of normal and diseased eyes. The fungi recovered most often were *Penicillium*, *Torula*, *Alternaria*, *Schizosaccharomyces hominis*, *Haploglyphium* and

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1 Fazakas, A. Fungi Found in the Lacrimal Canaliculi, on the Eyelids and in the Margins of the Lids, *Klin Monatsbl f Augenh* **104** 59, 1940.

2 de Saint-Martin. Mycosis of the Lacrimal Passages, *Medecine* **17** 32, 1936.

3 Carsten, P. Fungous Concretions in the Lacrimal Canaliculi, *Ztschr f Augenh* **62.25**, 1927.

4 Talice, R. V. Primary Mycotic Concretions of the Lacrimal Canaliculi. Report of a Case, *Ann de parasitol* **14** 164, 1936.

5 Elliott, A. J. Streptothricosis of the Lacrimal Canaliculi, *Am J Ophth* **24** 682, 1941.

6 McClanahan, A. Fungus Infection of the Lacrimal Canaliculi, *Am J Ophth* **19** 418, 1936.

7 Reese, W. S. Concretions of the Lacrimal Canaliculus, *Pennsylvania M J* **38** 772, 1935.

8 Valière-Vialeix. Chronic Conjunctivitis Produced by Undetected Mycelian Concretions of the Lacrimal Canaliculi. Report of Cases, *Bull Soc d'opht de Paris* **49** 298, 1937.

9 Brinkerhoff, A. J. Actinomycosis of the Inferior Canaliculus, *Am J Ophth* **25** 978, 1942.

10 Fazakas, S. Study of Fungi Cultured from Conjunctiva, Cornea, Lid Margin and Lacrimal Passages, *Arch f Ophth* **133** 461, 1934.

*Aspergillus*, in descending order of frequency. Although of the fungi recovered in cases of lacrimal obstruction these forms were likewise the commonest, it cannot be assumed that they are necessarily the primary cause of the obstruction. *Actinomyces* is the fungus most often encountered in concretions of the canaliculi. Blastomycotic infection of the eye is extremely rare. Two cases in which *Candida* was present were recorded by Fazakas in a series of 404 cases of fungous infections of the eye. One of these was a case of acute conjunctivitis. In the second case the organism was cultured from an anophthalmic socket. Brownlie<sup>11</sup> described a case of sprue (thrush) (*Candida albicans*) involving the lacrimal sacs, antrums, tonsils, mouth and parotid glands. The bilateral acute dacryocystitis subsided without treatment and without stricture of the nasolacrimal ducts. The infection was mixed with staphylococci and *Proteus vulgaris*. Search of the available literature has yielded no description of obstruction of the nasolacrimal ducts by *Candida*.

#### REPORT OF CASES

**CASE 1**—A white woman aged 25, in excellent health, was seen in June 1945 for a complaint of epiphora of the right eye of about twenty-four hours' duration. General physical and special nasal examinations revealed no abnormality. Ophthalmic examination showed a normal condition except for minimal hyperemia of the bulbar and palpebral conjunctiva and moderate epiphora of the right eye. The puncta and canaliculi were normal. Pressure on the lacrimal sac produced no discharge. Irrigation through the lower punctum resulted in return of the solution through the upper punctum. As irrigation was continued the patient complained of a slight pain along the side of the nose and requested permission to blow the nose. As she did so, there appeared a cylindric cast of the nasolacrimal duct, about 16 mm long and 3 mm in diameter, in color and consistency resembling soft dough. The folds of the nasolacrimal mucosa were represented by shallow indentations along the cast. There was immediate cessation of epiphora, and the passage could be irrigated freely. No obstruction was present on the opposite side. Some type of mycotic obstruction was suspected. A nitrazene paper test of the tears gave a  $pH$  of 7.3 for each eye. After the first irrigation the patient remained free from symptoms, and no other treatment was given. Three weeks after relief of the obstruction the lacrimal passages were again irrigated and the washings were collected for culture. Washings from the nose alone were also cultured. None of these showed any growth of fungi in twelve days. The patient has remained well for seven months.

**Laboratory Observations**—A small, yellowish white, cylindric mass was submitted to the laboratory for examination. The mass, resembling a cast, was firm and round and tapered from one end to the other.

A small portion was first examined by the hanging drop method and with the Gram and dilute "carbolfuchsin" (phenol-fuchsin) stains. These preparations

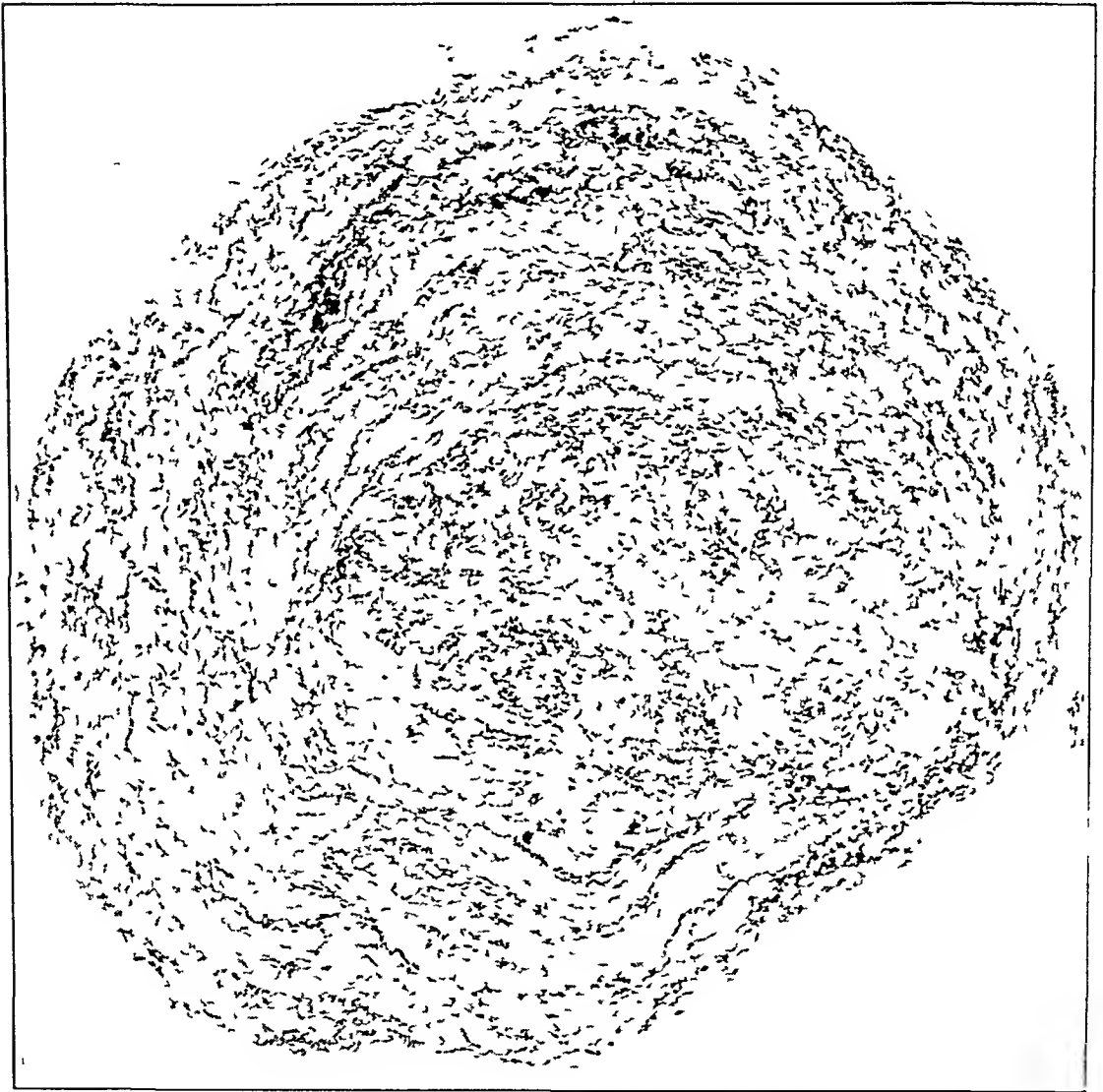
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<sup>11</sup> Brownlie, W. B. Case of Infection of the Lacrimal Sacs, Maxillary Antra, Tonsils, Mouth and Parotid Caused by *Blastomyces Albicans* (Thrush), *J. Laryng, Rhin & Otol* **34** 26, 1919.

showed it to be composed almost entirely of budding, yeastlike cells with a few scattered cocci and diphtheroids

A second portion was fixed sectioned as for tissue and stained by the Gram-Weigert method Examination revealed principally yeast cells with very little epithelial debris and a few bacteria (figure)

The remaining portion, taken for culture, was washed once in sterile isotonic solution of sodium chloride to reduce external contamination and inoculated on two large tubes of Sabouraud's dextrose agar, one tube each of corn meal agar,



Cross section of cast washed from the nasolacrimal duct, composed almost entirely of yeast cells (*Candida albicans*)

wort agar and malt agar, and a blood agar plate One tube of Sabouraud's agar and the blood agar plate were incubated at 37 C and the rest at room temperature (about 25 C)

After twenty-four hours the blood agar plate showed numerous colonies of staphylococci and diphtheroids All other cultures showed a beginning growth of species of *Candida* after about three days After incubation for a week all tubes were covered with luxuriant growth of these yeasts Transfers were made for purposes of purification and identification according to the methods of Martin



and associates<sup>12</sup> During the subsequent period of subculture it was noticed that a few colonies of an orange variety began to make their appearance. These were also subcultured with the idea that they might be mutants or a new species of *Candida*. Complete cultural studies showed the white species to be *C. albicans*, but the orange species could not be identified in our laboratory. It was therefore sent, together with the culture of *C. albicans*, to the department of mycology at Duke University Hospital for study. This institution reported the white species to be *C. albicans* and stated that an identification of the orange species could not be made except that it was a member of the fungi imperfecti and resembled a common air-borne contaminant which has been observed in slime formation during wood pulp processing.

It is our opinion that *C. albicans* was the causative organism in the formation of the cast and that the orange organism was either a minor commensal or a contaminant from the nose acquired when the cast was expelled through that organ. Whether *C. albicans* was the primary causative organism in formation of the cast or was secondary to an earlier process brought about by staphylococci, diphtheroids and other organisms or trauma cannot be stated, but there is no doubt that this yeastlike fungus caused the "mechanical" formation of the cast, since the latter was composed almost entirely of yeast cells of this type.

CASE 2—One of us had previously encountered a similar instance of mycotic obstruction of the nasolacrimal duct. The patient, a white woman aged 49, presented the signs of subacute dacryocystitis with stenosis of the nasolacrimal duct. She gave a history of an episode of lachrimation about six months earlier which was relieved spontaneously after blowing of her nose and the appearance of a whitish, cylindric body from the nose. Repeated irrigations of the sac did not relieve the obstruction. About three weeks after the onset, as the dacryocystitis was subsiding, after another apparently unsuccessful attempt to irrigate the lacrimal passage, the patient blew from her nose a grayish white, cylindric cast, 1 cm long and 2 mm in diameter. There was immediate restoration of the patency of the nasolacrimal duct. Microscopic examination of the material showed it to be made up of spherical, yeastlike cells with numerous buds. Unfortunately, circumstances did not permit identification of the organism in this case.

#### SUMMARY

Two cases of mycotic obstruction of the nasolacrimal duct are described, with identification of the yeast as *C. albicans* in 1 case. Recovery was spontaneous and immediate following extrusion of the castlike obstruction of the duct. One is led to speculate whether other spontaneous cures of obstruction of the nasolacrimal duct or cures following a single probing may not have a similar explanation.

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12 Martin, D. S., Jones, C. P., Yao, K. F., and Lee, L. E. A Practical Classification of the Monilias, *J. Bact.* 34:99, 1937.

# FIELD OF VISION IN CHRONIC GLAUCOMA

## A Comparison of Fields with Full and with Reduced Illumination

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SYRACUSE, N Y

IN 1931, observations on 11 cases of chronic glaucoma showing the effect of reduced illumination on the field of vision were reported<sup>1</sup> The present review has to do with 50 additional cases studied by the same method

The possibility that examination of the fields of vision with reduced illumination might reveal earlier changes is not a new idea In his bibliography Duke-Elder<sup>2</sup> cited a paper by Haffmans,<sup>3</sup> published in 1861 Stargardt<sup>4</sup> had used this procedure in 1906 Ferree and Rand,<sup>5</sup> in 1922, suggested the advantages of taking fields at more than one intensity of illumination In 1925 Edmund and Moeller<sup>6</sup> published the fields in a case of glaucoma, showing the effect of a graded series of photometric dark glasses Traquair,<sup>7</sup> although he stated the belief that the use of small visual angles gives as much information, expressed the opinion that reduction of the illumination may considerably accentuate relative defects in certain pathologic conditions In discussing darkroom perimetry, he suggested that "since impairment of the light sense is, as far as we know, the earliest symptom of impaired nerve conductivity, it is possible that there may be a field in the future for perimetry in reduced light in the diagnosis of the incipient stages of many conditions affecting the visual path" Duke-Elder<sup>2</sup> referred to the possibility of

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Candidate's thesis for membership, accepted by the Committee on Theses of the American Ophthalmological Society

1 Marlow, S B Visual Fields in Chronic Glaucoma Effect of Reduced Illumination, Arch Ophth 7:211 (Feb) 1932

2 Duke-Elder, W S Text-Book of Ophthalmology, St Louis, C V Mosby Company, 1938, vol 3, p 3384

3 Haffmans, J H A Arch f Ophth 8 (pt. 2) 124, 1861-1862

4 Stargardt, in Schieck, F, and Brückner, A Kurzes Handbuch der Ophthalmologie, Berlin, Julius Springer, 1930, vol 2

5 Ferree, C E, and Rand, G Am J Ophth 5 455, 1922

6 Edmund, C, and Moeller, H U Arch Ophth 54 531, 1925

7 Traquair, H M An Introduction to Clinical Perimetry, London, Henry Kimpton, 1927, p 41

demonstrating certain changes in the field with dim light Passow,<sup>8</sup> in 1932, described a darkroom campimeter with exact regulation of light intensity He pointed out the advantage of the method in making an early diagnosis of changes in the visual fields, especially in cases of prodromal glaucoma, and in noting the progress of the disease Livingston,<sup>9</sup> in 1943, reported the application of Passow's work in the study of the field at high altitudes Barr,<sup>10</sup> in 1940, confirmed the general principle that reduced illumination is desirable in studies of the fields He attempted to vary the amount of light which stimulated the central and peripheral parts of the retina in equal amount, basing his studies on the work of Hecht

Little attention, other than the statement that good general daylight is essential in examination of the field of vision, had been given to the effect of varying amounts of light until Ferree and Rand called attention to its importance They showed that the variation in the amount of light on the same or on different days may result in a variability of 28 or 30 degrees in some meridians of the field They designed a perimeter combined with a tangent screen in which a constant and even illumination of 7 foot candles was obtained Although Duggan<sup>11</sup> (1940), in discussing the value of perimetry and in presenting tables for small test objects and their field limits, made no reference to the amount of illumination, he advocated noting the amount used Thomasson<sup>12</sup> advocated use of artificial illumination in order that uniform results might be possible, especially when following up cases He made no recommendation as to the amount of light desirable except to suggest that it be standardized Quantitative perimetry has become generally accepted and more or less standardized as to the size of the test object and the distance of the screen, but not as to the intensity of illumination The amount is seldom noted

Whether or not the changes in the visual fields in glaucoma are due to disease of the rods or cones is difficult to determine It is the generally accepted view that they are due to defects in the nerve fiber (impaired conduction) What part irradiation plays in bringing out early changes with reduction of illumination is hard to determine Every nerve impulse, whether motor, sensory or proprioceptive, has the same characteristic, that is, the response is of the all or none type It is possible, therefore, that with reduced illumination the stimulus

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8 Passow A Dark Room Campimeter with Exact Regulation of Light Intensity, *Arch Ophth* 9 151 (Jan) 1933

9 Livingston, P C *Tr Ophth Soc U Kingdom* 63 51, 1943

10 Barr, H L Some Fundamental Physiologic Principles in Study of Visual Field, *Arch Ophth* 24 10 (July) 1940

11 Duggan, W F Tangent Screen Scotometry Value in Diagnosis, Prognosis and Evaluation of Therapy, *Arch Ophth* 23 316 (Feb) 1940

12 Thomasson, A H *Arch Ophth* 55 545, 1926

tion irradiation may be below the threshold of stimulation for neighboring cells. The sensitivity of the test is thereby greatly increased and is therefore capable of revealing earlier defects. Whatever the explanation, it must be admitted that in the study of a case of glaucoma the more information that can be obtained from any source, the better that case will be understood. If it is true that changes in the fields are found only after the disease is established (Traquair), then perimetry as ordinarily practiced should not be expected to be of assistance in diagnosis of the incipient stages of the disease. In this early stage the fields are known to be normal. It is when the disease is in the incipient stage that changes in the fields can be brought out with the reduction of illumination when they are not demonstrable, or are doubtful, with the usual methods of examination.

The sensitivity of tests of the field of vision can be varied in three principal ways. The first has to do with variations in the size of the test object and the distance at which the test is made. The investigations of Bjerum, Ronne, Traquair, Walker, Thomasson and Duggan are too well known to need recapitulation. The second is exemplified by the work of Ferree and Rand, who demonstrated the effect of contrast with various colored backgrounds and test objects. Wessely<sup>13</sup> showed that defects for red and blue can be demonstrated on the tangent screen earlier than defects for white. The third variable concerns the illumination. Combinations of these principles offer further possibilities, so that it is not possible to agree with Duggan's<sup>11</sup> statement that "the only way to increase the sensitivity of the perimetric test will be to increase the radius of the perimeter, since there is a practical limit to the size of the test objects obtainable." Few workers specify the amount of illumination desirable for perimetry. Ferree and Rand designed their perimeter for a uniform, constant illumination of 7 foot candles. In the clinical application of his experimental work, Bair used a neutral tint Wratten filter of 3 per cent transmission over a Bausch and Lomb tangent screen illuminator, which gives an estimated brightness of the tangent screen of about 0.003 millilambert as measured with the Macbeth illuminometer. In the present report, a brightness of 0.20 foot candle was selected because it was found that the field of normal subjects for 1/1,000 (1 mm test object at 1 meter) was not affected by such an intensity. This intensity is close to the zone in which the rods and cones function equally.

#### METHOD

The patient is seated about 3 feet (90 cm) from a wall, with two windows equidistant behind him as the source of light. The light is controlled by Venetian blinds, which are let down and heavy drapes pulled together, leaving a vertical source of light on each side of the patient. A screen similar to that described

13 Wessely, K. *Klin Monatsbl f Augenh* 79-80 811, 1927-1928

by Thomasson (a Duane tangent screen stretched on a frame placed on a stand) is then placed at a distance of 1 meter from the patient. With a Sharp foot candle meter held close to the surface of the screen, the Venetian blinds and drapes are then adjusted to register 0.20 foot candle on the photometer. All these adjustments are made in semidarkness so as to allow time for adaptation. After the final adjustments are made, a few minutes' wait is allowed before the actual mapping of the field is begun. A 1 mm test object is first tried. If this cannot be seen under the conditions of illumination, the smallest object that is visible is then selected for the test. If the field for this test object is small, the field of a still larger test object is plotted. Immediately after the determination and charting of the field with reduced light the test is repeated with full illumination, by which is meant that the curtains are opened as wide as possible, the amount of light available being recorded by the foot candle meter. This full

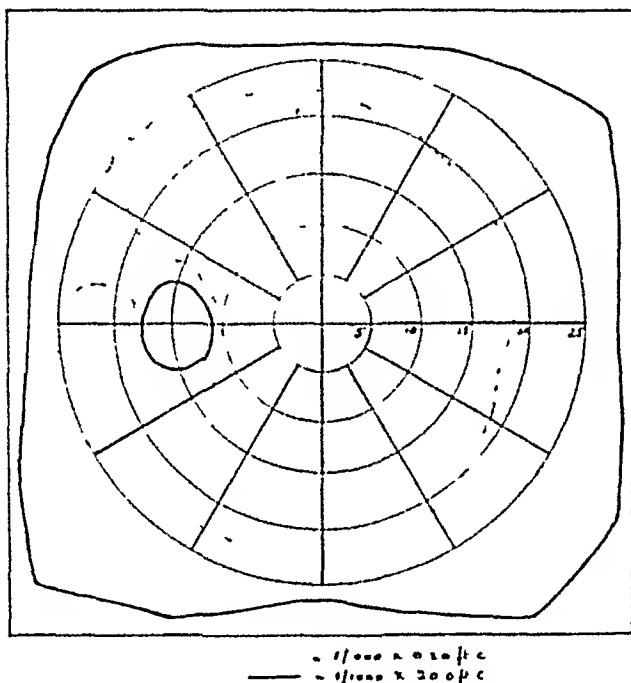


Chart 1—Right eye, vision 6/8, tension 38 mm. Beginning of barring of the blindspot in the 1/1,000–0.20 foot candle test and some contraction of the field, as compared with a normal blindspot and full field in the 1/1,000–20.0 foot candle test. No scotomas could be detected.

illumination varies considerably, depending on whether or not the day is cloudy. Records show that it may vary from 10 to 40 foot candles. The fields under the two degrees of illumination are then compared.

#### OBSERVATIONS AND ANALYSIS

Charts 1 to 13 illustrate the kind of change which it is possible to detect by the reduction of the illumination in what Traquair called the preperimetric stage of the disease, as compared with the condition of the field with good illumination. Traquair<sup>14</sup> expressed the opinion

<sup>14</sup> Traquair, H. M. Clinical Detection of Early Changes in Visual Field. *Arch. Ophthalm.* 22: 947 (Dec.) 1939.

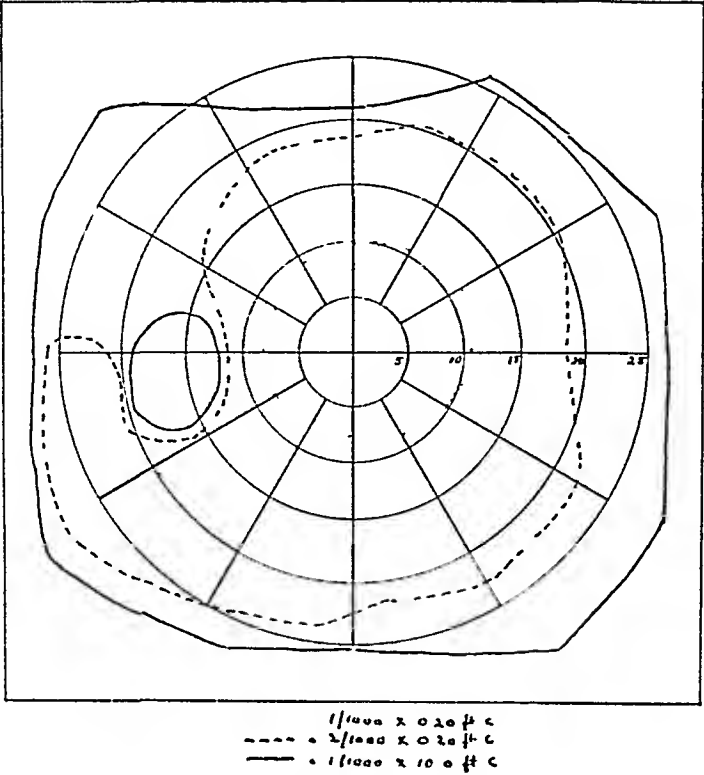


Chart 2—Right eye, vision 6/6, tension 33 mm Baring of the blindspot in the 2/1,000-20 foot candle test, the 1/1,000-20 foot candle field being too small The 1/1,000-100 foot candle field shows slight contraction only

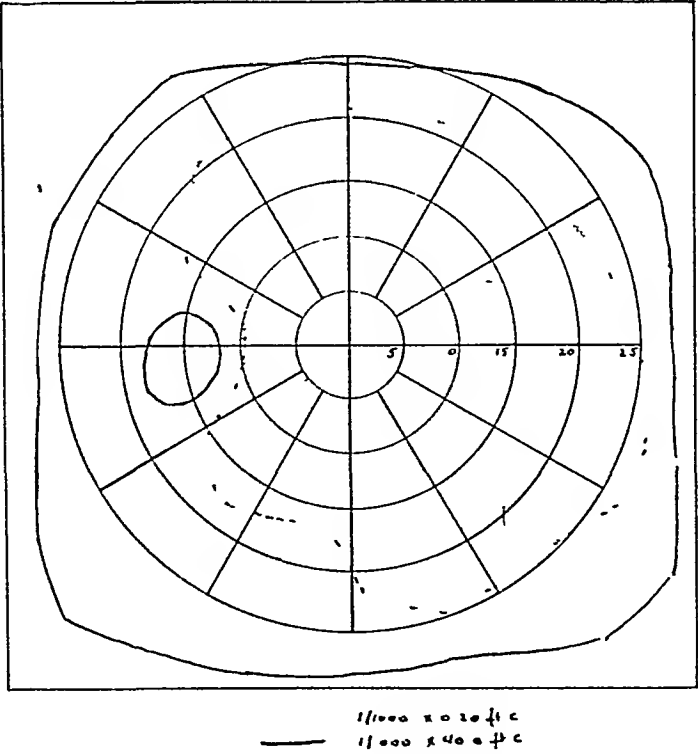


Chart 3—Right eye, vision 6/6, tension 19 mm More complete baring of the blindspot

that barring of the blindspot is one of the earliest signs in glaucoma and that it can be discovered only by careful testing with the screen at a distance of 2 meters and with a 1 or 2 mm test object. In chart 1 no defect in the field could be found until the illumination was reduced, when the barring of the blindspot became evident, as shown. Chart 2 demonstrates barring of the blindspot with a larger test object in a second case. Chart 3 is an example of the same condition at a more advanced stage in a third case. Chart 4 indicates the progress in the last case after four years, there being little change in the field with good light

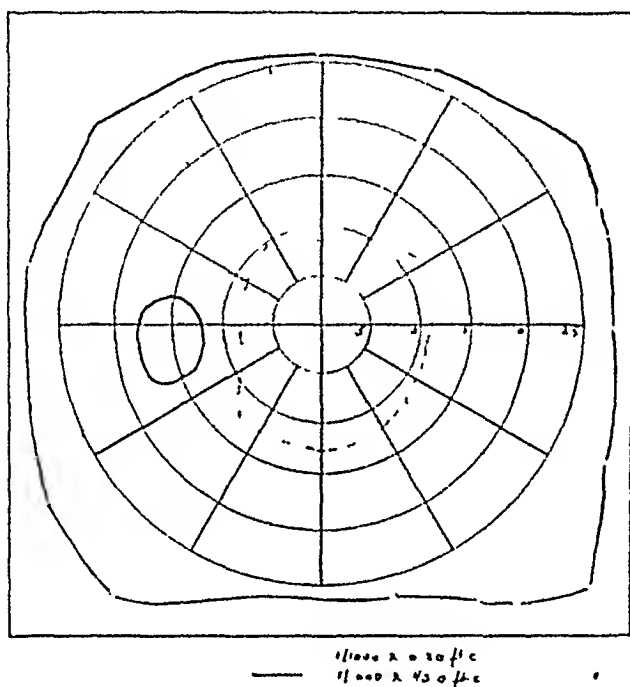


Chart 4—Same eye as that shown in chart 3, three and one-half years later, vision 6/5, tension 12 mm. The 1/1,000-40 foot candle field shows no change, whereas the 1/1,000-20 foot candle field is further contracted.

Ronne called attention to the formation of a nasal step as one of the early signs characteristic of glaucoma. In chart 5, with full light only slight contraction of the field and a somewhat large blindspot are evident. With reduced light a nasal step was definitely outlined with the two different-sized test objects used, none being apparent otherwise.

"Arcuate scotomata," according to Traquair,<sup>7</sup> "may develop at a relatively early stage of the disease." In chart 6 only a moderate contraction of the field and a somewhat elongated blindspot were demonstrable in good light. The chart illustrates a greatly contracted 1/1,000-20 foot candle field with a typical nasal step. The 2/1,000-0.20 foot candle field is only slightly smaller than the 1/1,000-40 foot candle field.

foot candle field, but an arcuate scotoma together with an enlarged blindspot could be delineated. It is of interest to note that the nasal end of the scotoma abuts on the edge of the nasal step of the 1/1,000–0.20 foot candle field. In chart 7 an arcuate scotoma without any peripheral change is shown in the 1/1,000–20.0 foot candle field. With the 1/1,000–0.20 foot candle test the scotoma is shown to be much larger, with barring of the blindspot in the lower temporal quadrant.

The relative sensitivity of the test is indicated by chart 8. In this case the 1/1,000–0.20 foot candle and 2/1,000–0.20 foot candle fields have been lost. The 3/1,000–0.20 foot candle field is overlapped by

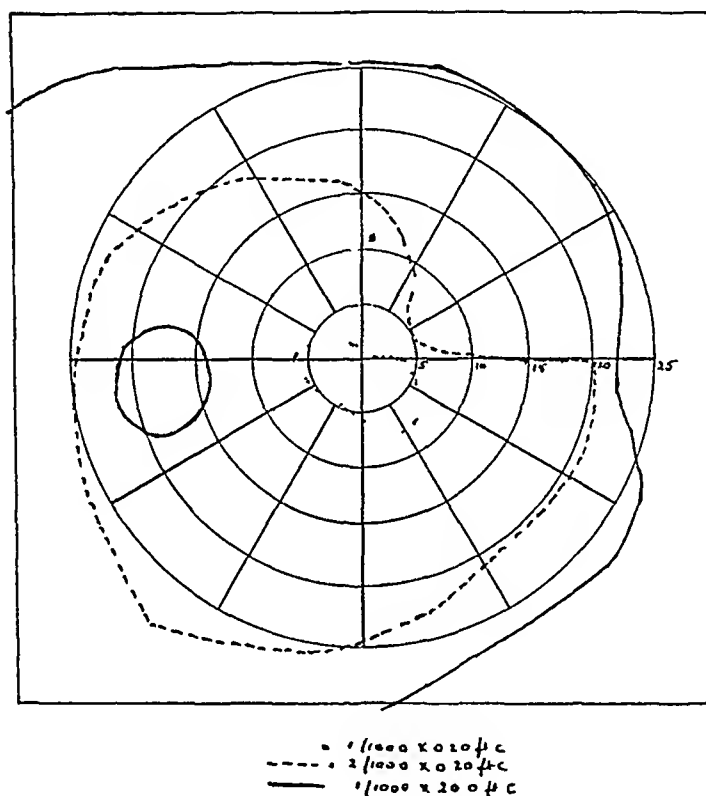


Chart 5—Right eye, vision 6/6, tension 22 mm. No defect in the field with the possible exception of a large blindspot in the 1/1,000–20.0 foot candle test. When the light is reduced to 0.20 foot candle, the 1/1,000–0.20 foot candle field is very small, with a nasal step, which is duplicated in the larger, though contracted, 2/1,000–0.20 foot candle field.

the 1/1,000–40.0 foot candle field, which shows only moderate depression. Chart 9 is another example of the same condition. In these 2 instances the reduction in intensity of illumination to 0.20 foot candle has made the test three times as sensitive as the test with full illumination, as determined on the basis of the size of the test object used.

The greater sensitivity of the test from the viewpoint of the factor of time is well shown by comparison of charts 10 and 11. The 1/1,000–0.20 foot candle field in chart 10 is almost exactly the size of the 1/1,000–10.0 foot candle field in chart 11, taken six years later. The



evidence that progressive changes are going on, in other words, is more easily shown by reducing the light Charts 12 and 13 further illustrate this point

The 50 cases studied by the method described can be divided into three groups The first includes the cases in which the duration of the disease prior to observation could be estimated from the history and in which the diagnosis was well established There are 28 cases in this group

The second group includes 12 cases in which the duration of the disease could not be determined either because there was no history

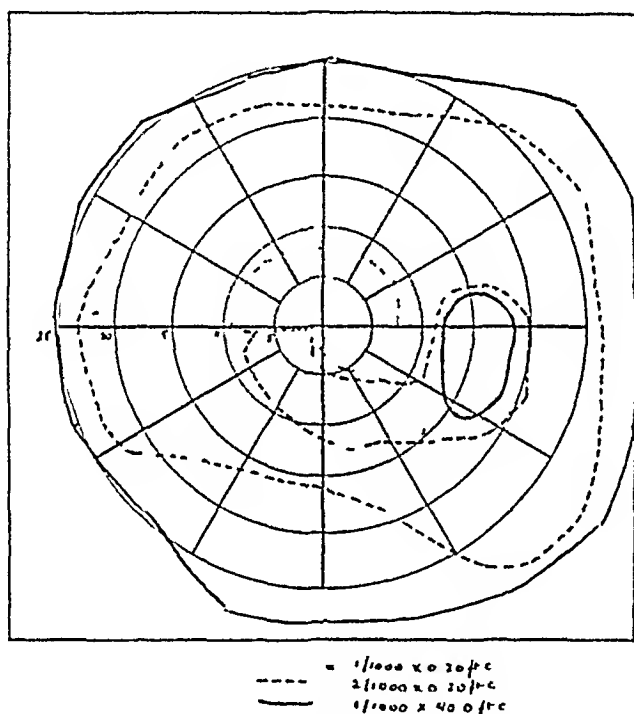


Chart 6—Left eye, vision 6/6, tension 35 mm No defect with the possible exception of a rather large blindspot in the 1/1,000–40.0 foot candle test A careful search failed to uncover any scotoma In the 1/1,000–0.20 foot candle test a very small field with a nasal step is outlined The 2/1,000–0.20 foot candle test reveals an arcuate scotoma reaching from the enlarged blindspot to the edge of the nasal step of the 1/1,000–0.20 foot candle field The limits of this field are also somewhat constricted

or because the cases were studied from the standpoint of diagnosis These cases might be said to be instances of the early stage in which the diagnosis was definitely established

In the third group are 10 cases in which glaucoma was suspected The method was used to prove or disprove the diagnosis In some of these cases the condition has subsequently been found not to be glaucoma

Analysis of the visual fields in the three groups of cases may be summarized as follows Of the 28 cases of glaucoma of estimated

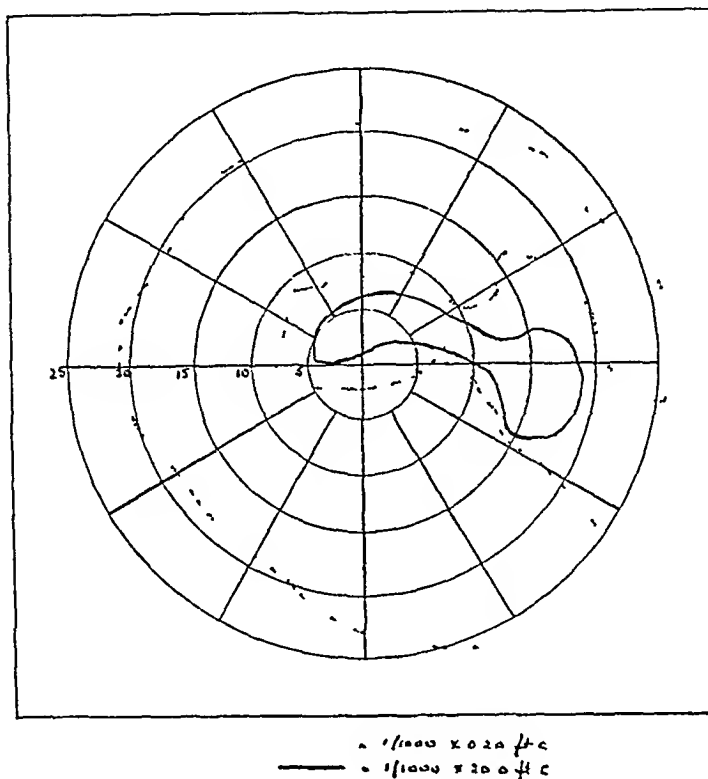


Chart 7—Left eye, vision 6/6, tension 18 mm. Scotoma connected with the blindspot in the 1/1,000-0.20 foot candle test without any contraction of the field. The 1/1,000-20.0 foot candle test shows a much larger scotoma with baring of the blindspot below and definite constriction of the field.

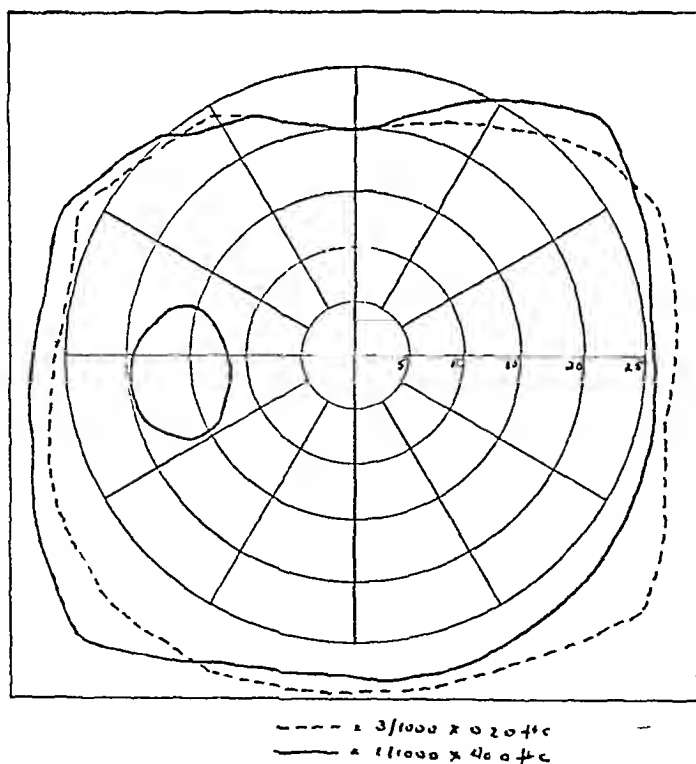


Chart 8—Right eye, vision 6/8, tension 12 mm. Overlapping of the 1/1,000-40.0 foot candle field and the 3/1,000-0.20 foot candle field. The 1/1,000 and 2/1,000 fields with 0.20 foot candle illumination are lost. Changes have progressed so that at the time the field was taken an object three times as large was necessary to map the field. This suggests that reduction of illumination has made the test three times as sensitive.

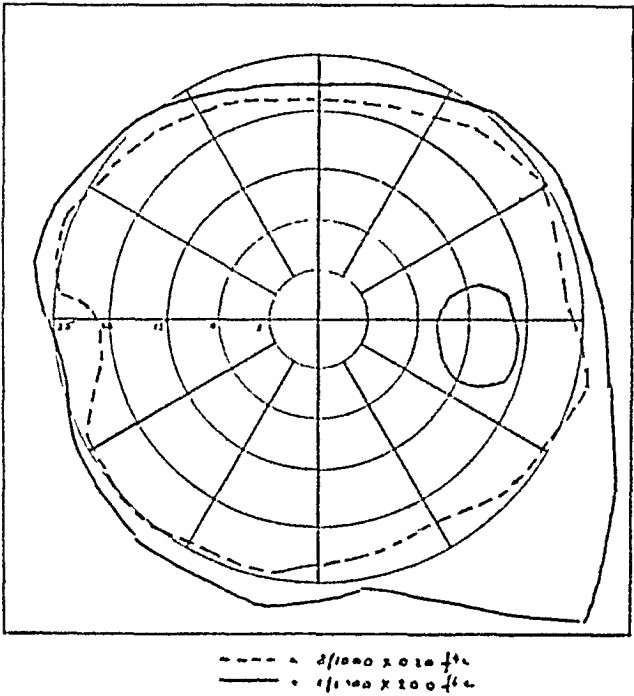


Chart 9—Left eye, vision 6/6 +, tension 32 mm Close correspondence between the 1/1,000-200 foot candle field and the 1/1,000-0.20 foot candle field Smaller test objects were not visible with reduced light

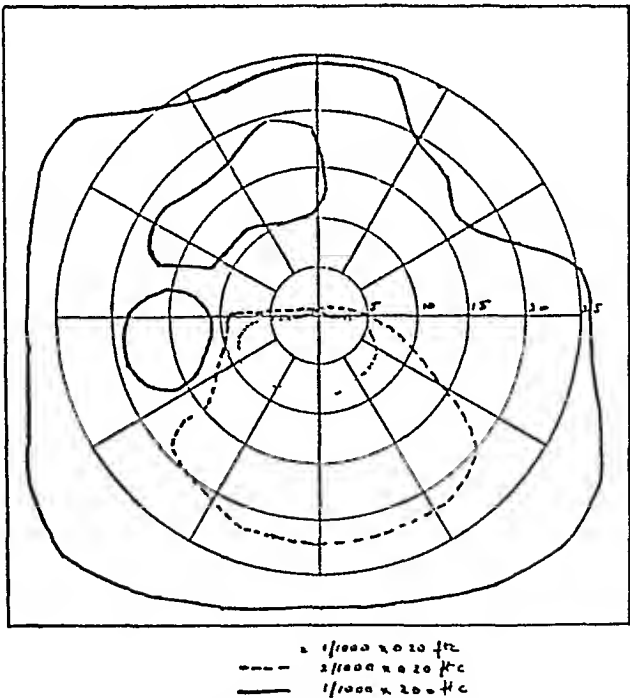


Chart 10—Right eye, vision 6/5, tension 20 mm The 1/1,000-0.20 foot candle field anticipates by six years the state of the 1/1,000-0.20 foot candle field in figure 11

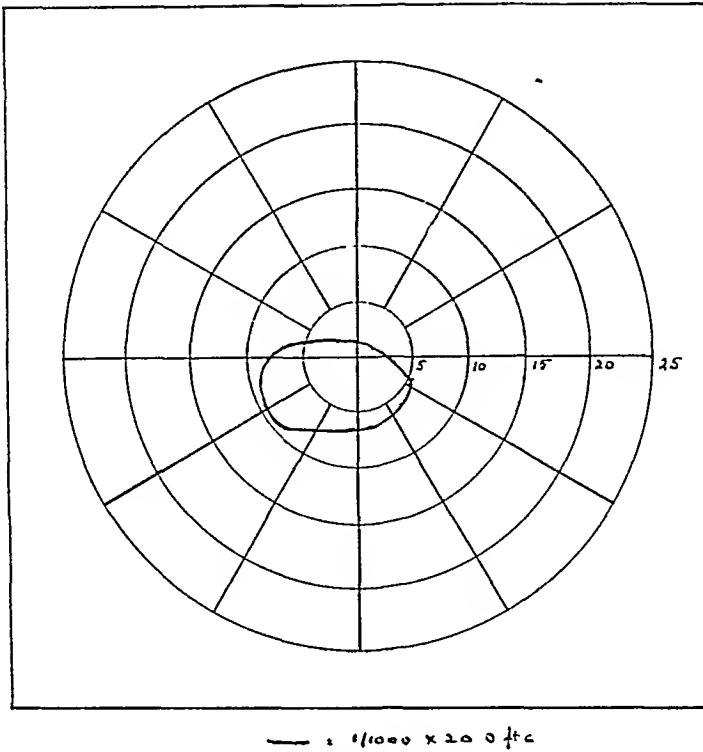


Chart 11—Right eye two years after operation, vision 6/9, tension 19 mm. The field for this eye taken six years before is given in figure 10. The 1/1,000–200 foot candle field is now about the same size as the 1/1,000–0.20 foot candle field in figure 10.

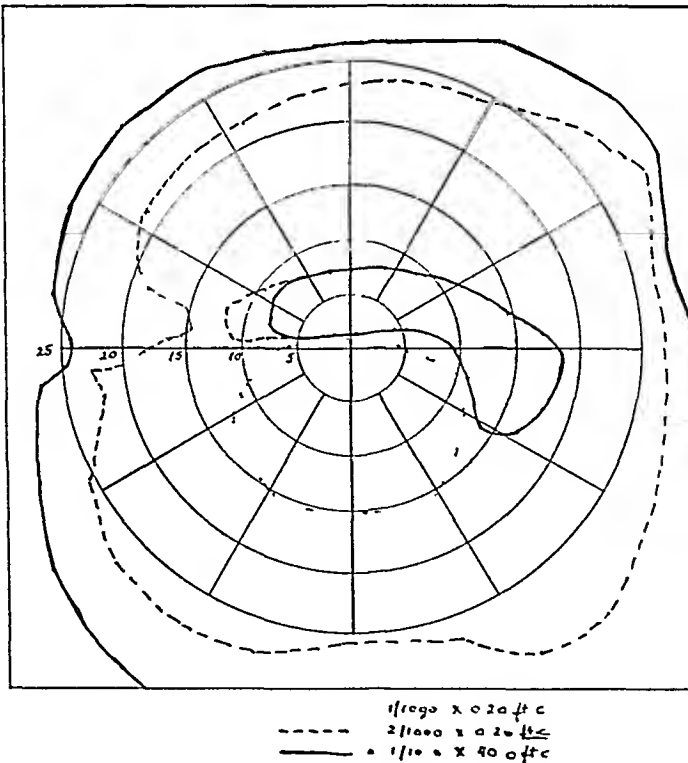


Chart 12—Left eye, vision 6/6, tension 30 mm. Little peripheral contraction with the 1/1,000–400 foot candle test, but an arcuate scotoma is connected with the blindspot. The 1/1,000–0.20 foot candle field is rather small. The 2/1,000–0.20 foot candle field is almost as large as the 1/1,000–400 foot candle field and has an indentation directed toward the arcuate scotoma, which extends toward this area in this test, there being only a suggestion of a connection, too indefinite to outline.

duration, there were 15 in which changes were shown in the field of the better eye with reduced light only, indicative of glaucoma. Of these 15 cases, vision was as low as 6/15 in 1, 6/9 in another and 6/6 or better in the rest. Tension was as high as 40 mm in 1 case only and was within normal limits in the rest. There was no cupping in 11 of these 15 cases. Well established glaucoma was present in the worse eye. Changes in the field of the worse eye were demonstrated with reduced light only in 6 cases. Cupping was absent in 4 of these 6 cases, tension averaged somewhat higher than in the rest of the 15 cases. These observations indicate that changes in the fields can be detected with reduced illumination before cupping and high tension are demonstrable. In the well

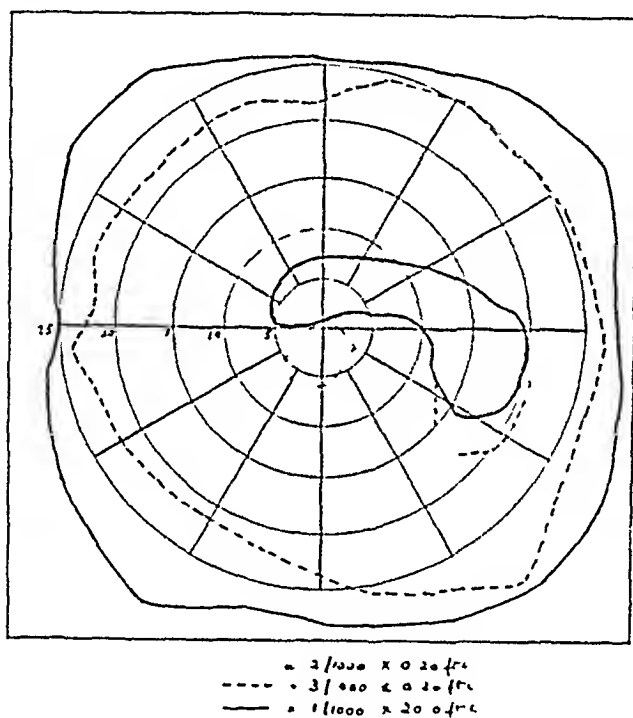


Chart 13—Left eye, vision 6/6, tension 18 mm. Field taken six months later than that in chart 12. The 1/1,000-200 foot candle field is fairly full. The arcuate scotoma and blindspot have changed little. The 1/1,000-0.20 foot candle field has gone, the 2/1,000-0.20 foot candle field being much smaller than the 1/1,000-0.20 foot candle field was six months previously. The 3/1,000-0.20 foot candle field is now about the size of the 2/1,000-0.20 foot candle field in chart 13. These two fields show definite evidence of progression with reduced light, whereas with full illumination the condition of the field has changed little.

established cases of glaucoma the value of the method is greater in following the course of the disease than in the diagnosis. In the remaining 13 cases in this group the diagnosis was evident not only in the greater visual failure and the higher tension but in the more advanced changes in the fields, both with reduced and with full illumination. In these cases the method added information on the state of the disease but did not aid in diagnosis.

Of 12 cases of glaucoma of uncertain duration and a definitely established diagnosis, the field of the better eye was observed to be defective with dull light in 7, with full illumination in 1 and with both in 2, there being no contraction of any sort in 3. Of these 12 cases, vision in the "better" eye was 6/9 or more in all but 2 (6/12 and 6/15), the highest tension being 36 mm and the lowest 12 mm. There was evidence of cupping in the better eye in 4 cases only. Vision was 6/9 or better in the worse eye in only 5 cases, tension was much higher, with cupping present, in 7 cases, 1 eye having been enucleated. In 1 case only did the field of the "worse" eye show changes with dull light alone. Three of the eyes had vision too low to permit plotting the fields, the remaining 8 eyes showing grosser changes.

In 10 cases of glaucoma of uncertain duration in which the diagnosis of glaucoma was not established at the time of examination, or subsequently, vision was better than 6/16 in all but 1 of the eyes (unilateral high myopia). Tension was within normal limits in all but 1 eye, there was no unquestionable cupping. In 15 eyes the fields showed changes in dull light not characteristic of glaucoma. In only 1 eye was there evidence of a change in field with full illumination. In these cases the changes in field found with dull illumination were not sufficiently distinct to warrant a positive diagnosis.

#### COMMENT

The necessity for control of the illumination in examination of fields of vision in cases of chronic glaucoma would seem obvious, yet too little attention has been directed to it. The amount of light available should be recorded, whether natural daylight or artificial illumination is used. The value of reduced light in demonstrating early field defects characteristic of glaucoma in what Traquair calls the preperimetric stage of the disease is suggested by the charts and the analysis of the cases studied.

The method used in this study was developed so that it could be available for application without the need of special apparatus except an instrument for measuring the amount of illumination, such as the Sharp foot candle meter. The use of two vertical sources of light equidistant from the screen gives a uniform illumination free from shadows. The principle can be applied by any other method, as has been done by Bair. The important consideration is the measurement of the illumination. In this study a 0.02 foot candle was selected, for the reason stated. Some other intensity, greater or less, may eventually prove to be more desirable. The method is simple and capable of application in any office or clinic.

The evidence presented here permits the conclusion that reduction of illumination is more than sometimes useful and that it is of definite

value in the discovery of incipient changes, as well as in the amplification of known or suspected defects. It is, moreover, of greater value than other methods in the demonstration of progressive changes. It is to be regretted that a comparison with the screen test at 2 meters with good light in the same case is not available. However, Traquair<sup>14</sup> stated that "the effect of reduction of illumination is more pronounced when the screen is used, especially at greater distances, as, for example, with a 1/3,000 or 2/3,000 test." This statement can be construed to suggest that reduction of illumination is valuable no matter what the distance of the screen.

Whatever differences of opinion may exist, it must be conceded that the illumination used should be measured and recorded.

1023 State Tower Building

# CENTRAL PULVERULENT (DISCOID) CATARACT AND ITS HEREDITARY TRANSMISSION

ANDREW RADOS, M D  
NEWARK, N J

IN 1906 Nettleship and Ogilvie<sup>1</sup> published an extensive study of the occurrence of a congenital cataract in the Coppock family. The first observation on this familial anomaly was made by Doyne, who had the opportunity of examining the first, second and third, and possibly fourth, cases in this family between 1888 and 1896. Members of the family were affected by a definite and peculiar type of stationary congenital cataract, which showed but slight variation in clinical appearance. Most typically it was characterized by the presence of a disk-shaped opacity of steel gray color in focal light and almost homogeneous texture, though often sparkling or stippling was noticeable, the opacity made the fundus invisible or, at best, only dimly discernible. In size, shape and clearance of outline the second variety was identical with the first but was so extraordinarily faint that detection could have been missed even with the pupil dilated and the fundus readily visible. In the third variety, the diameter of the disklike opacity was less, its outline, though circular, was slightly irregular or eroded, and the texture, though translucent, was granular. The type of the disk-shaped opacity was not fixed in all instances in which parent and children were affected or in the affected members of the same sibship. Thus, V-11 had the third, or small, variety with irregular outline, his daughter (VI-38) exhibited the first, or large dense, form, the younger daughter (VI-42), the second, or transparent, variety, again, a woman (IV-10) and her youngest child (V-31) were afflicted with the first variety, while her 2 oldest children (V-26 and V-28) showed the third form, designated as such by the authors.

The cataract was always bilateral and symmetric in the two eyes of the same person, it was stationary, without any signs of progressiveness, the youngest patient was 10 and the oldest 82. The large type of disk was of sufficient size to obstruct the ordinary pupil of 4 mm diameter. The classification by competent observers varied from a small lamellar opacity to an opacity of the posterior capsule. Nettleship and Ogilvie observed only a single layer of opacification, the layer itself was always thin but of varying degrees of transparency, and was

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From the Ophthalmic Department of the Beth-Israel Hospital

1 Nettleship, E., and Ogilvie, M. F. A Peculiar Form of Hereditary Congenital Cataract, *Tr Ophth Soc U Kingdom* 26 191, 1906



situated behind the nucleus but well in front of the posterior capsule. Although regularity and sharpness of outline were suggestive of lamellar opacity, the evidence of the presence of a second layer, either in complete form or in the form of riders, could never be furnished, and therefore the opacity was distinctly different from lamellar cataract. The authors went a step further in emphasizing the difference between this cataract and the lamellar type by stating that the opaque disk cannot be the representative of a lamellar cataract with coalesced layers after absorption of the center, for then the opacity would be confined to the nucleus, observations with the parallactic test and focal illumination, however, agree in placing the disk definitely behind the nucleus. Localization behind the nucleus antedated by many years the accurate localization made available through the use of the slit lamp and was based on methods available at the time of the study. These methods, needless to say, were much inferior and were almost archaic as compared with the accuracy of localization afforded with the use of the slit lamp, a fact which will be discussed at greater length in a later section.

Members of the family with multiple occurrence of the disk-shaped opacity were described as of healthy stock, bright, intelligent, over the average in height and girth and exceeding the average in duration of life, rickets and syphilis were absent, the teeth were good, and there were no physical anomalies. One epileptic person was found among 300 members of the family noted. Similarly, in other large family trees showing the anomaly, no physical deviations from normal were observed, only Rosen<sup>2</sup> mentioned the association of camptodactyly with the cataract in 1 case. Camptodactyly has occasionally been mentioned with other forms of congenital cataract, such as the floriform type. The simultaneous occurrence of cataract and anomalies of the fingers was noted, but the genetic linkage is unexplained and, according to Waardenburg,<sup>3</sup> is often more than doubtful. Visual acuity was not much lowered because of the condition.

Of the two original pictures, presented by Nettleship and Ogilvie,<sup>1</sup> the first presents the typical variety, a circular, somewhat conical, opacity at 5 o'clock, the second, an atypical form, with perfectly circular outline and a triradiate opacity of greater density than the rest. The triradiate figure was evident in only 1 opacity, 2 or 3 others showed only a slight indication of it.

In the same year (1906) Levy<sup>4</sup> reported a case in which, in the center of each lens, in the position of the nucleus or immediately behind

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2 Rosen, E. Coppock Cataract and Cataracta Pulverulenta Centralis, *Brit J Ophth* 29 641, 1945

3 Waardenburg, P. J. *Das menschliche Auge und seine Erbanlagen*, Haag, Nijhoff, 1932

4 Levy, A. Unusual Congenital Opacities in Both Lenses, *Tr Ophth Soc U Kingdom* 26 74, 1906

it, a circular opacity of 3 mm diameter, with clearcut edges, yellowish amber color and somewhat granular appearance, was visible

Nettleship,<sup>5</sup> in a second paper published two years later, proposed the designation of "Coppocks cataract" for working purposes and that of "discoid (Dojne) cataract" for descriptive purposes. Whereas in the original paper dealing with the Coppock family the anomaly was described as a distinct entity, differing from the lamellar variety, in the second paper a pedigree was presented in which lamellar cataract, discoid cataract and retinitis pigmentosa (pigmentary degeneration of the retina) affected various members of the same family, some discoid cataracts in this series were not large enough to block the pupil, other opacities, described as lamellar, reached 4 mm in diameter, and others exceeded even that diameter. Of the 32 congenital cataracts, 24 (16 in males and 8 in females) were designated as lamellar and 8 (3 in males and 5 in females) as discoid. The pedigree showed 275 persons (110 males and 115 females with the sex of 50 unrecorded). All the members were the descendants of 2 brothers and their respective wives.

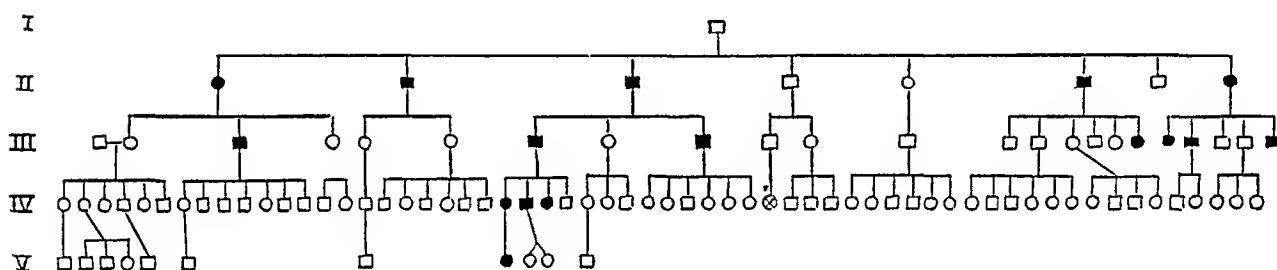


Fig 1—Pedigree of Nettleship and Ogilvie, showing central pulverulent (discoid) cataract

In this figure, and in the accompanying figures, hollow squares indicate males not examined, hollow circles, females not examined, black squares, affected males, and black circles, affected females

The pedigree was divisible into two parts, the larger portion (180 persons) consisting of the members afflicted with cataract, and the smaller portion (150 persons) including the members with retinitis pigmentosa (15 persons), the two conditions overlapping to a slight extent in some cases. The two conditions were not causally related, each having been introduced by a different ancestor from an independent source. All cataracts were traceable to the 2 brothers, the retinitis pigmentosa was found only in the descendants of 1 of the 2 brothers and was brought in by his wife, for whom the data are outstanding. The sex incidence and the mode of inheritance of the two diseases were different. Cataract affected more males (19 males and 13 females) and was usually

5 Nettleship, E. Lamellar Cataract Coppock or Discoid Cataract and Retinitis Pigmentosa Affecting Different Members of the Same Family, *Tr Ophth Soc U Kingdom* 28 226, 1907-1908

transmitted through the father (the affected father in 6 cases and the unaffected father in 1 case), it was transmitted through the affected mother in 1 or 2 cases, through the unaffected mother in 2 cases and through both parents in 1 case. The descent was continuous except in 2 cases. Retinitis pigmentosa, similarly, affected more males (13 males and 3 females), but the descent was without exception a discontinuous one and was transmitted through the unaffected mother. The collocation of discoid cataract with the ordinary lamellar variety was the outstanding phenomenon, presenting itself in two sets of cousins, in 2 brothers and in a brother and sister (III 28 and 30 and IV 50 and 56, respectively).

In his Bowman lecture, Nettleship<sup>6</sup> described the discoid opacity as occupying only a small fraction, possibly one twentieth or less, of the entire lens. He stated that the malign influence, whatever its nature, acts on the lens in the earliest stage of its development, possibly even before the closure of the lens cup, and the range of action is so limited as to damage no other part of the epiblast, or any part of the mesoblast other than the minute portion concerned in the nutrition of the rudimentary lens. On the basis of the pedigrees, showing the more frequent transmission through the male, the influence of the male parent seems to be the more important. Nettleship reversed his previous opinion, presented in collaboration with Ogilvie, which was based on the pedigree of the Coppock family, and stated that discoid and lamellar cataracts were identical anomalies, not independent forms. He asserted that the discoid cataract is the smallest possible variety of the lamellar type, so minute that two layers are united or indistinguishable, the position of the disk, or flattened lamella, at a deeper level than the nucleus of the normal lens, but well in front of the posterior capsule, remaining without satisfactory explanation. In other words, Nettleship did not change his opinion about the localization, he concluded only that discoid, or Coppock, cataract was not a distinct entity, but purely a smaller variety of the lamellar cataract. In accordance with this view, the lamellar cataract may be prenatal or postnatal, the hereditary form developing toward the end of fetal life. The diagnosis of lamellar cataract was made definitely by Horner in the case of a child 6 weeks of age, but has been made as early as two weeks after birth. The size of the lamellar cataract is intimately connected with the time at which the lesion acted on the lens, the diameter of the lens being 3.3 mm in the fourth month, 4.5 mm in the sixth month and 5 mm in the seventh month, of fetal life, reaching 7.5 mm at birth. An opacity measuring 6 mm must, necessarily, have developed after birth because it corresponds to a lens of 7 mm, the

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6 Nettleship, E. On Some Hereditary Diseases of the Eye (Bowman Lecture), *Tr Ophth Soc U Kingdom* 29 Ivii, 1908-1909

diameter before the shrinkage of the nucleus, which represents the first stage of formation of the opaque perinuclear layer

In the American literature, Chance<sup>7</sup> (1907) was the first to report opacities of the lens like those described by Nettleship and Ogilvie, the cataract occurring in a father, 3 of his 5 sons and his only daughter. The opacities were of the same kind in each instance and measured about 4 mm in diameter, they were bilateral and without exception accurately symmetric in the two eyes. The author's description, however, does not correspond with the plates in his paper. For instance (figure 2 in plate XI), the opacities in the father's eyes are of similar nature but not accurately symmetric, the opacity in the right eye having a horizontal reniform shape, with a hilus at the lower border, and the opacity in the left eye being almost circular, with flattened base. The cataracts appeared to be stationary, the disks were of almost the same thickness, and the localization was that given in the previous reports. The color corresponded to that of boiled sago, and the disk was of minutely granular consistency and was

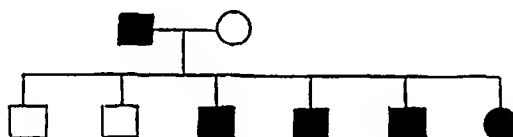


Fig 2—Chance's family with discoid cataract in both eyes of the father and of 4 of his 6 children

translucent. In 1 of the cases in this family, clumps of opacities appeared in one eye, and the denser masses formed an indefinite star in the lens of the other eye. In 1 of the cases the disk was extremely thin, as though the result of simple condensation, whereas in the last case circular vacuoles were noted.

Smith<sup>8</sup> observed the cataract first demonstrated by Doyne in members of a family not related to the Coppocks. He described it as discoid and retronuclear and as varying in size in different members of the family, the very slight, lamellar opacity was not observed. The youngest affected member was 3 and the oldest 64 years of age. Harman<sup>9</sup> described the opacities as small and close to the nuclear region, in cases in which definite lamellar structure was observed the opacity was small in relation to the total size of the lens, sharply defined and without borders.

7 Chance, B. Unusual Form of Hereditary Congenital Cataract in Several Members of a Family, *Arch Ophth* 36 505, 1907

8 Smith, P. A Pedigree of Doyne's Discoid Cataract, *Tr Ophth Soc U Kingdom* 30 37, 1910

9 Harman, B. Congenital Cataract. Pedigree of Five Generations, *Tr Ophth Soc U Kingdom* 29 101, 1909

The first to describe this form of cataract was Doyne, who examined the oldest members of the Coppock family, almost twenty years later the same family was the subject of extensive study by Nettleship and Ogilvie. Soon it became evident that the anomaly did not occur in the descendants of the Coppocks only, as the family reported by Smith was in no way related to the Coppock family. "Doyne's discoid cataract" was suggested as a distinctive name for this congenital defect, for the term "disk-shaped cataract" had already been applied to another form of congenital cataract (in which the nucleus was entirely lacking and the lens was represented by a flattened, disklike structure, shaped like a dumbbell, with opaque central portion and clear periphery), and the name "Coppock cataract" is objectionable because it labels a congenital defect with the name of one family which presented the hereditary form of the anomaly.

The English and the American literature as reviewed contained numerous observations on the anomaly described. After the introduction of the slit lamp, the first description of a congenital form of cataract was that of Vogt<sup>10</sup> the author designating it as "*cataracta pulverulenta centralis*". In his first publication, Vogt stated that there was no similar observation in the entire ophthalmic literature except for a case reported by von Hess as one of lamellar cataract, in which the opacity was only 2 mm in diameter, and therefore probably of similar nature to that in his case. The central nucleus of the opacity was given as 0.72 mm and the peripheral ring as 1.04 mm in diameter. Both sections were sharply outlined, the dots appearing delicate and surrounded with a light ring and the opacity being located in the space between the anterior and the posterior suture. The part of the lens to be affected is the embryonic nucleus, and therefore the oldest part and the opacity necessarily develops in the first months of fetal life. In the central part the dots exhibited a radial arrangement, there were larger dots, measuring 0.1 mm. Peripheral to the outer ring, and about 3 mm from it, traces of a third ring of the opacity were discernible. In the first edition of Vogt's "Atlas" there is an excellent picture, the equatorial diameter of the entire opacity is given as 2.2 mm, the central, denser, opacity measuring 0.8 mm. The embryonic sutures were not visible. The opacity, probably congenital, was composed of dustlike and punctate dots, the central, opaque nucleus was more rounded in the sagittal direction than the less dense layer peripheral to the nucleus (fig. 235 c and d). In the second edition of his "Atlas,"<sup>11</sup>

10 Vogt, A. *Atlas der Spaltlampenmikroskopie des lebenden Auges mit Anleitung zur Technik und Methodik der Untersuchung*. Berlin, Julius Springer, 1921, *Arch. f. Ophth.* **107** 196, 1922.

11 Vogt, A. *Lehrbuch und Atlas der Spaltlampenmikroskopie des lebenden Auges*, Berlin, Julius Springer, 1931, vol. 2, p. 438.

3 cases are illustrated (1 of which is identical with the case in the first edition) showing the apparent increased density of the equator (figs 967 *a* and *b*, 968, 969 and 970) In the new cases there were a few larger opacities in the form of large white dots, furthermore, the circumference was not strictly circular, one opacity showed a slight bulging in the directions of 6 and 7 o'clock If one compares this opacity with the conical opacity described in the first case, the typical picture of Nettleship and Ogilvie, one finds them extremely similar When one compares the pictures presented by the two authors the similarity is more than striking The circular, sharply marked outlines, the slight conical form, directed downward, the dustlike, gray, dense opacities, and the absence of larger clumps are identical One wonders whether there can be any other explanation than that offered by the two authors, belonging to different language groups and unaware of the fruits of each other's labor Based on the description of the new form of cataract given by Vogt, a series of articles appeared on the morphologic character of central pulverulent cataract in the German and Italian literatures (Poos,<sup>12</sup> Rauh,<sup>13</sup> Hanssen,<sup>14</sup> Peterdy,<sup>15</sup> Favaloro,<sup>16</sup> Russo<sup>17</sup>), in which the authors took it for granted that the anomaly in question had never been observed prior to Vogt's publications The vast English literature was entirely overlooked, in spite of the fact that Gifford,<sup>18</sup> as early as 1924, pointed out that examination with the slit lamp in the older cases would have proved that the affected part was actually the embryonic nucleus and that the opacity would fall into the class of "congenital embryonal nuclear cataract" (as disclosed by the slit lamp, with a small beam of lamp) described by Vogt The publication of Gifford, which will be discussed later in more detail, was overlooked again, possibly because of its being published in English At this point attention must be directed to the fact that Gifford treated the same subject in a second paper (1927), this time written and

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12 Poos, F. Ueber eine familiar aufgetretene besondere Schichtstarform "Cataracta zonularis pulverulenta," *Klin Monatsbl f Augenh* **76** 502, 1926

13 Rauh, W. Doppelseitige Cataracta pulverulenta mit symmetrischer Nebentrübung, *Klin Monatsbl f Augenh* **83** 38, 1929

14 Hanssen, R. Beiträge zur pathologischen Anatomie der Linse (Cataracta pulverulenta), *Ztschr f Augenh* **76** 73, 1932

15 Peterdy, E. M. Sulla cataratta zonulare pulverulenta, *Arch di ottal* **36** 35, 1929

16 Favaloro, G. Cataratte embrionali e fetali, zonulari, centrali (contributo clinico e biomicroscopico), *Ann di ottal e clin ocul* **64** 721, 1936

17 Russo, A. Contributo alle cataratte congenite, ereditarie e familiari sulla cataracta centralis pulverulenta, *Ann di ottal e clin ocul* **63** 105, 1935

18 Gifford, S. R. Congenital Anomalies of the Lens as Seen with the Slit-Lamp, *Am J Ophth* **7** 678, 1924

published in German,<sup>10</sup> but the authors were still unaware of the facts pointed out by Gifford

Poos<sup>12</sup> observed the anomaly in the lenses of both eyes of a mother and 4 daughters (the fifth child, a son, was not examined) In the mother's case the cloudy area measured about 2 mm, only one concentric layer was affected, the center and the periphery of the lens remained transparent The cloudiness was denser at the periphery and diminished toward the central part The opacities were dustlike, punctate and powderlike, with a distinct regularity, the size of the individual opacities increased toward the periphery In the oldest daughter the cataract showed the same texture, but the opacity measured 3.5 mm The principal zone of cloudiness was surrounded peripherally by a second layer of more delicate opacities The demarcations toward the equator and, similarly, toward the anterior and posterior bulging surfaces were extremely sharp The opacity in the case of the second daughter strongly resembled that in the previous case, except that here there was a larger, irregularly shaped, opacity in the center of each lens, a feature which was lacking in the other members of the family The lenses of the third daughter showed the characteristic opacity, with the difference that the main zone of the opacification was denser and the external ring extremely faint In the case of the youngest daughter the opacities were very delicate and occupied only a single layer The pictures were identical in the two eyes of the same person

The multiple layers of cloudiness are common to the lamellar type of cataract, but they differ in the minuteness and regularity of the component elements, furthermore, in the absence of radial opacities, the ridges, which are so characteristic of the perinuclear cataract, are not present Poos identified the cases with those described by Vogt but pointed out that in Vogt's presentation the center of the lens showed an even denser accumulation of the minute dots and that in his (Poos's) cases, with 1 exception the center was as free from the opacities as the clear periphery The opacities in Poos's cases were in multiple layers, considering this arrangement, he proposed the designation *cataracta zonularis pulverulenta*

In the case of Rauh<sup>13</sup> the opacity did not show the characteristic picture He observed in the lenses a delicate, spherical opacity consisting of extremely minute, white dots, with some greenish or reddish shimmering in the central part The density of the opacity was greatest in the central portion and diminished toward the equator, which was not sharply defined The opacity occupied the site of the embryonic nucleus, the posterior sutures were well defined, and the anterior sutures

19 Gifford, S Zum kongenitalen Star des Embryonalkerns, Klin Monatsbl f Augenh 78 191, 1927

were hardly discernible. The zones of discontinuity of the embryonal nucleus were sharp. The central opacity disclosed a visible interval, producing the appearance of a central opacity surrounded by a wide saucer. Downward from the embryonic nucleus in each lens, and symmetrically located, was a second distinct, small round opacity enclosed in a homogeneous layer but isolated from it by a clear zone consisting of dots identical with those in the larger spherical opacity of the embryonic nucleus. This second (small) opacity was within the zone of discontinuity of the embryonic nucleus. The anterior and posterior cortical layers contained a few punctate opacities. The small opacity in the lower part of the lens, the punctate structure of which was identical with that of the primary, large opacity of the embryonic nucleus, deserves special consideration, because in zonular opacities the lamellar nature always discloses parallelism, not only of the lamellas but even of the isolated opacities, the riders are concentric with the center of the lens.

It is questionable whether the case of Hanssen,<sup>14</sup> cited solely because of its being the only case in which histologic examination could be reported, really belongs to the group under discussion. The author himself considered the possibilities of zonular, or central pulverulent, cataract, or of the senile premature punctate cataract of Becker or of a juvenile cataract progressing through senile changes. Both lenses were affected in his case, but in very different degrees (vision was 4/6 in the right eye with a correction of  $-3.50$  D and was limited to counting fingers at 1 foot [30 cm] in the left eye). The central opacity consisted of powder-like dots, a narrow, but clear, ring of cortex was sharply differentiated from the cloudy central area. Cloudiness extended into the periphery, the fundus was visible only with maximum dilatation of the pupil. The delicate cloudiness was most pronounced at the periphery but was also present throughout the entire nucleus. The left lens was extracted intracapsularly, and section through the center revealed clear cortex, sharply demarcated toward the center, which contained numerous small, cloudy dots, becoming less dense toward the center. Under high magnification, small empty spaces of various configurations, round, oval, angular and irregular with granular content, were seen. The average space measured 8 to 15 microns, some were larger, with septum-like divisions. In the periphery of the cloudy portion the outlines of the lens fibers were indistinct, and at times invisible, they were in better state of preservation toward the center, with wavy outlines and empty spaces between the fibers. Lime salts were not present, examination for lipids was not possible.

The features of the case do not justify classifying the anomaly as a central pulverulent cataract, histologic examination of the latter form of cataract has not been made, which is not surprising considering that it represents a nonprogressive anomaly, causing only slight visual disturbance.



Omitting the casuistic publications of purely descriptive observations, one must consider again the work of Gifford, which presented for the first time the connecting link between the material gathered in the relatively older English literature and the more or less recent German literature, stimulated by Vogt. Duke-Elder<sup>20</sup> described the discoid cataract and stated simply that the appearance with the slit lamp had been described by Vogt. With the ophthalmoscope, Gifford observed in his patient, a woman aged 54, a circular, sharply circumscribed opacity, 2 mm in diameter, in the center of the pupillary area of each lens. The opacity was not very dense, the fundus opacity corresponded to the anterior surface of the embryonic nucleus, the anterior and posterior sutures were invisible. The opacities consisted of white dots of varying sizes, surrounded individually by a brighter ring, the denser central area was relatively larger than in the first case of Vogt, and there was no differentiation of a shell separated by a clearer layer from the denser central portion. The keen observation of Gifford led him to the conclusion that the central pulverulent cataract described by Vogt is identical with an anomaly observed in England and in the United States and designated as Coppock cataract, Doyné's discoid cataract or familial nuclear cataract. The diagnostic criteria are the size of the opacities, their texture and their exact location within the lens. The first two did not escape the attention of the older observers, whose armamentarium consisted only of focal illumination and the parallactic phenomenon, and the employment of the slit lamp gave Vogt and later observers the possibility of localization within the embryonic nucleus. In his second paper (published in German) Gifford reiterated his opinion as to the possible identity of Vogt's cataract with the type described in the English literature, a consideration emphasized for the first time but, nevertheless, totally ignored in the German literature, even in the second edition of Vogt's "Atlas," which appeared many years later. The second paper of Gifford contains interesting data, in 1 of the 4 typical isolated cases the patient had a son with perinuclear cataracts, a relation similar to that existing between the two forms reported previously by Nettleship and Harman. In 1 family the mother and daughter were similarly afflicted, but the opacity was somewhat larger, about 3 mm in diameter, with visible anterior and posterior sutures, as described by Vogt.

Morphologically, this anomaly of the lens affects the ontogenetically oldest part, the embryonic nucleus, and is a true idiokinetic malformation. The diameter of the opaque zone, which often represents a double line, varies within certain limits, measuring on the average from 2 to 4 mm.

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<sup>20</sup> Duke-Elder, W. S. *Text-Book of Ophthalmology*, St. Louis, C. V. Mosby Company, 1938, vol. 2, p. 1368.

Members of the same family afflicted with the anomaly present opacities of various sizes. Poos reported that in the case of the mother the opacity measured approximately 2 mm, the equivalent of the outer zone of the embryonic nucleus, and in the 4 daughters the central zone was twice this size, with a second zone of cloudiness, of still larger diameter, in 3 of the 4 cases. Two cases of Vogt were similar to the cases of Poos, the opacity in the first affecting the embryonic nucleus and that in the second showing two zones of more diffuse opacities around the central zone, similar to that in the third case of Poos. Nettleship and Ogilvie, who observed the largest number of cases within a single family, emphasized the presence of only slight variations and gave an excellent clinical description of the three varieties, they recognized the possible variation of the types in parents and children, or among affected members of the sibship. Vogt, in a much smaller number of members of the affected family observed that the hereditary anomaly was identical, not only in size and location of the opaque zone but in the outlines and texture of the cloudiness, the double contour and the minute dots with the presence of larger elements. The latter assumption seems to be in diametric disagreement with the literature (Nettleship and Ogilvie, Chance, Poos and others) and with the findings in a family which I observed. The central pulverulent cataract is always bilateral and identical in the two affected lenses of the same person except for the slightest individual variations. The bilateral appearance is important, considering the resemblance of the structure to a zonular arrangement and the possible relation, therefore, to zonular cataract and the possibility of transitional forms between the two types. The early observers in the English literature described a single layer of opacification, but the advent of the slit lamp proved in many cases the presence of a second, or even a third, ring of dots encircling the central opaque zone. Poos suggested the designation of *cataracta zonularis pulverulenta*, Russo, that of a central pulverulent opacity. Similarly, Bellows<sup>21</sup> observed a case with numerous fine dots of equal size in the embryonic nucleus surrounded by a concentric, peripheral ring of hooklike, radial opacities. The proximal portions of the hooks appeared to be wider than the distal, presenting angular opacities (riders) in association with the central pulverulent cataract. Nettleship and Harman pointed out the alternating occurrence of the two types in the same family, and, similarly, Gifford reported a case in which the son has been operated on for zonular cataract.

Even in the complicated cases, in which the cataract is associated with coralliform cataract or with cataracts of other types, occurrence is

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21 Bellows, J. G. *Cataract and Anomalies of the Lens*, St. Louis, C. V. Mosby Company, 1944.

always bilateral Mann<sup>22</sup> stated that zonular cataract is bilateral, but other authors, such as von Szily,<sup>23</sup> were undoubtedly not mistaken in their opinion that the typical zonular cataract occasionally appears as a unilateral lesion. I recall few cases of unmistakably unilateral lamellar cataract in young children, true, this type may be hereditary or acquired, and the possibility of proving the presence of unilateral hereditary cataract of this type has not yet been investigated. The question of such a possibility will be the task of future observation and research. From the standpoint of modern genetics, one must consider the possibility, as known hereditary anomalies, such as polydactyly, ptosis of the upper lid and coloboma may occasionally show unilateral manifestation.

In the second family of my observation, the complicated form of central pulverulent cataract was, accordingly, present in both eyes of the members so affected. To my knowledge there is no proof in the literature of the presence of unilateral appearance.

The sharply defined area consists of minute dots in the embryonic nucleus, surrounded by a slight halo. Occasionally larger dots are mingled with the minute ones. The opacity may be steel gray and densely stippled, or very thin and translucent or very small and granular, the process is not progressive and remains unchanged throughout life. In young children and in old persons the morphologic character does not undergo any variation. The visual disturbance is usually slight, Jess<sup>24</sup> being the only one to describe the visual disturbance as considerable. The early observers described the cataract as a flat disk situated between the nucleus and the posterior pole, but always separated from the latter by clear cortical layers. The true morphologic character was not disclosed before the employment of the slit lamp, when the biconvex appearance, involvement of the embryonic nucleus and the multiple layers of dots became generally known. In this connection, it is of interest that Adams<sup>25</sup> had the opportunity to examine 1 member of the Coppock family with the slit lamp. In this patient the opacity was a fairly dense, spotted, circular disk, the slit lamp disclosing its biconvex nature, with involvement of the embryonic nucleus. The minute dots appeared white in the beam of the slit lamp, with a more or less clear central area. The anterior and posterior sutures could not

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22 Mann, I. *Developmental Abnormalities of the Eye*, London, Cambridge University Press, 1937.

23 von Szily, A. *The Contribution of Pathological Examinations to Elucidation of the Problem of Cataract (Doyne Lecture)*, *Tr Ophth Soc U Kingdom* (pt 2) 58:595, 1938.

24 Jess, A. *Die Erkrankungen der Linse*, in Schueck, F., and Bruckner, A. *Kurzes Handbuch der Ophthalmologie*, Berlin, Julius Springer, 1930, vol 5, p 201.

25 Adams, P. H. *Doyne's Discoid Cataract (Coppock)*, *Brit J Ophth* 26:152, 1942.

be definitely identified. According to Adams, the nature of the opacity was that of a very small lamellar cataract, a finding which appears fairly often. Bursuk<sup>26</sup> expressed the belief that the central pulverulent cataract was a *forme fruste* of the zonular type.

The size of the opaque disk varies. Mann, who did not mention central pulverulent cataract, but spoke only of disciform, or Coppock, cataract, stated that it must form at or before the sixth month of fetal life. Bellows<sup>21</sup> simply reproduced Mann's table of the times of appearance of abnormalities. It seems that the varying size of the opaque disk means the formation at different periods. In his Bowman lecture,<sup>6</sup> Nettleship pointed out, with regard to the lamellar cataract (page 60), that the size of the cataract is indicative of, and in direct association with, the time the lesion has acted on the developing lens. The smaller the opaque area, the earlier was the time of action which resulted in the anomaly. Gifford applied the same principle to the central pulverulent cataract, stating that in the small variety affecting solely the embryonic nucleus the origin of the anomaly must be placed as early as the third month, consequently, the larger zone of opacity indicates, accordingly, a later time for the action of the lesion, possibly the fifth or the sixth month of fetal life.

The original observation on the type of cataract in the Coppock family showed a dominant mode of inheritance, which is almost the general rule in hereditary forms of cataracts. Nettleship and Ogilvie's family consisted of 288 persons (131 males and 115 females, with 42 whose sex was not disclosed). The cataractous branch included 134 persons (71 males and 55 females, with 6 whose sex was not given), 90 (44 males and 40 females, with 6 whose sex was not stated) were examined, of whom 16 were afflicted (2 others who had died prior to the time of examination were apparently affected, too). The transmission of the anomaly was given as continuous in every instance—in 2 cases through two generations, in 1 case through three generations and in 1 case through four generations. Transmission was through the fathers in 4 cases and through the mothers in 3 cases. The 4 affected fathers produced 8 affected children out of 22, the 3 affected mothers, 5 cataractous children out of 12. The descendants of normal members of the family remained free from the defect. There were only 5 instances of cousin marriages in the entire pedigree. The cataract was present only in one branch of the stock. Although in 3 of 4 cousin marriages one of the cousins was a member of the cataractous branch, the cataract appeared only in the offspring of 1 of these matings, and in this single case one of the parents was affected, in the other cousin marriages, in

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26 Bursuk, N. Formes Frustes of Zonular Cataract, *Russk oftal zhur* 12: 485, 1930.

which neither parent was affected the children remained free. These circumstances exclude the possible role of consanguinity as a hereditary factor.

In the family observed by Chance<sup>7</sup> the father transmitted the condition to his third, fourth and fifth sons and to the daughter (the mother and the first and second sons were free). Other members of the family were not examined. The mode of inheritance represents dominance. In another family, under the observation of Nettleship,<sup>8</sup> consisting of 275 persons (110 males and 115 females, with 50 whose sex was unrecorded), 8 had discoid and 24 zonular cataracts. The details of the disease in the members of this family are given on page 59.

Smith<sup>8</sup> published the pedigree of another family afflicted with the same anomaly, but not related to the Coppocks. The cataracts were of the discoid or retronuclear variety, all fairly dense, the very slight and the lamellar type did not occur. The youngest member affected was 3 and the oldest 64 years of age. The family consisted of 113 persons (information was available on 102), and 26 were affected (24 of the 26 affected members and 49 of the 76 unaffected members were actually examined). One person, with 51 descendants, had 26 affected offspring (15 males and 11 females), an incidence of 50.9 per cent. With 1 exception, every affected person with offspring transmitted the anomaly, the exception being an affected man who had only 1 child. There was not a single instance in which unaffected parents produced an affected child. The defect was transmitted as a typical dominant character through three generations. In the first generation, an affected male produced in the second generation 3 affected females and 1 affected male. The first affected female of the second generation had 12 children, with 2 affected boys and 2 affected girls, the second affected female produced 2 normal and 2 affected sons, the third affected female had 8 children, with 2 affected sons and 1 affected daughter, the affected male had 11 children, of whom 5 sons and 2 daughters showed the anomaly. The third generation transmitted the discoid opacity only through the affected members, 1 affected male with 2 children, had an unaffected son, his brother had 5 children (2 males and 3 females) with 2 daughters and 1 son showing the disorder, 1 of the brothers had 1 unaffected child, and, finally, the affected female had 3 children (1 son and 2 daughters) with 1 affected son and 1 affected daughter.

Harman could observe the defect in five generations, 17 sibships with 63 persons in direct descent, 8 members died at birth or in infancy, and of the remaining 55 persons 19 were afflicted. As in the previous pedigrees, dominance was the mode of transmission. The affected persons

were always born to affected parents, no cataractous child had normal parents. The transmitters were both males and females. Of the 55 persons, only 36 could be examined, and therefore possibly more than the 19 persons were affected, explaining the shortage of 8 of the mendelian requirement. The opacities were small and close to the nuclear region; in cases in which it showed definite lamellar structure the opacity was small in relation to the total size of the lens, sharply defined and without riders. This family seems to furnish additional evidence of the interchangeability of lamellar and discoid cataract within affected families, similar to that in the family observed by Nettleship.

The German literature showed an apparent unawareness of the morphologic description offered by English and American authors, the hereditary factors concerning the anomaly were similarly overlooked, in some cases even up to very recent times. Vogt was at first entirely ignorant of a similar anomaly, later, in the first edition in his "Atlas," he stated that it was probably congenital, and in the second edition, he presented a pedigree of 1 of his cases but again failed to mention the

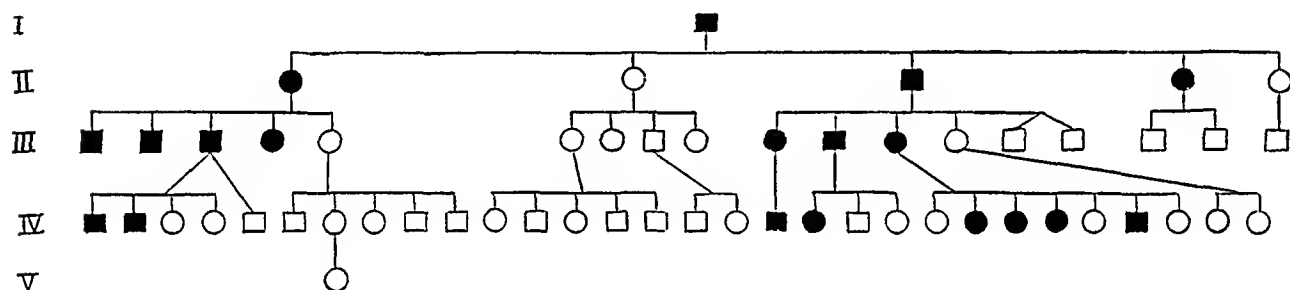


Fig. 3—Harman's family of 55 members, showing discoid cataract in 19

hereditary facts available. Prior to the publication of the second edition, however, Gifford's paper appeared in the German language, and Franceschetti<sup>27</sup> discussed Coppock and central pulverulent cataract in the same chapter, later Bruckner<sup>28</sup> stated that the two forms are probably identical. The familial appearance was noted in the cases of Poos (mother and 4 daughters affected), Gifford (mother with pulverulent cataract, and son with zonular cataract) and Vogt. Vogt's pedigree shows 5 generations, but actually only 3, members of the first and second generations not having been examined. Scrutiny of this pedigree permits the conclusion of unquestionable dominance of the anomaly if one of the unexamined parents of the second generation was affected. If one were to argue for recessiveness on the supposition that both parents were unaffected but were heterozygous for the anomaly, one must admit the extreme unlikelihood of inheritance of such a rare

27 Franceschetti, A. Die Vererbung von Augenleiden, in Schieck, F., and Bruckner, A. Kurzes Handbuch der Ophthalmologie, Berlin, Julius Springer, 1931, vol. 1, p. 631.

28 Bruckner, A. Tr. Internat. Ophth. Cong., 1938.

anomaly by this mode unless the parents are closely related, it is known that rare genes do not produce chance combinations in random matings. The familial appearance of this rare disease in children of unrelated parents can be interpreted only as an expression of dominance. Even the possibility that the parents carried the gene in suppressed form and the gene did not come to expression would, similarly, constitute evidence for dominance. In the third generation there were 3 affected and 3 normal children, representing a deviation from the expected 4:5:1:5 ratio, and not excluding the possibility of recessiveness. The deviation is of course insignificant, with such small numbers the calculation does not have much meaning, the 3:3 ratio not excluding the possibility of recessiveness, even if one were to expect the 3:1 ratio—characteristic of recessiveness. Nevertheless, the possibility of recessive inheritance can be discarded on account of the rarity of the gene and the nonconsanguinity of the parents. The family tree shows, in my

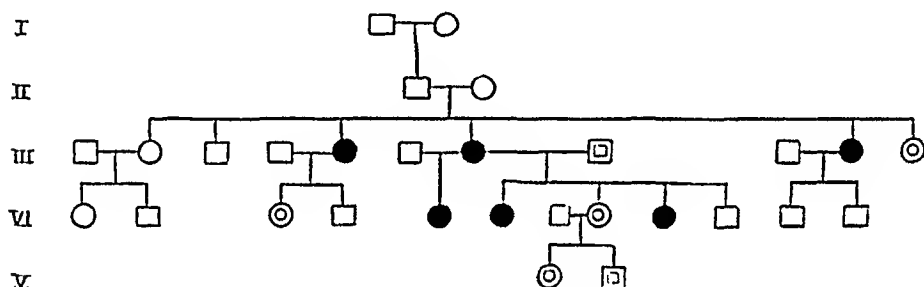


Fig 4—Vogt's pedigree, showing heredity of central pulverulent cataract

In this figure and in the following figures, the square within a square indicates males examined and not affected, and circles within circles, females examined and not affected

opinion, one deciding point for dominance—namely that the 1 affected female of the third generation in mating with 2 males (the first not examined, but supposed to be normal, and the second known to be normal) transmitted the disease to the only descendant of the first union and to 2 out of 4 children of the second union. Considering these facts, the pedigree must be interpreted as expressing dominance and one must assume that 1 of the unexamined parents of the second generation was so affected.

Moreover, as recessiveness cannot be maintained, the probability that mutation occurred in the third generation does not command any consideration. Whatever the cause of a mutation, whether a change in the quantity of gene, a change from one molecule into quite another, a partial change within the molecule, a change within the tridimensional arrangement of the molecule (formation of stereoisomers) or a quantitative change due to polymerization, one cannot imagine that the alteration of the extremely complicated mechanism within the gene would repeat itself exactly three times out of six within one sibship. But

even if, for argument's sake, one accepts the possibility of mutation in the third generation, the mutant genes, nevertheless, show dominances exclusively

The mode of inheritance seems to have been definitely settled as dominant in the older literature, only the recent literature, through unawareness of the facts, has seemed to obscure rather than to clarify the problem. Therefore the newer literature has been closely scrutinized and analyzed in the present study. Bucklers<sup>29</sup> dealt with Coppock cataract as a form distinct from the central pulverulent type. He claimed dominant inheritance for the former and cited Nettleship and Ogilvie<sup>1</sup> and Smith<sup>8</sup> each as having described it in 4 generations and Chance<sup>7</sup> and Harman<sup>9</sup> each as having reported it in 2 generations. Central pulverulent cataract, according to Bucklers, was dominant in 2 generations in families reported by Poos and Vogt, and he claimed the possibility of recessiveness for his observation, in which unaffected parents had 4 affected children (2 males and 2 females) in a family of 10 (6 females and 4 males). The observation is in agreement with that of

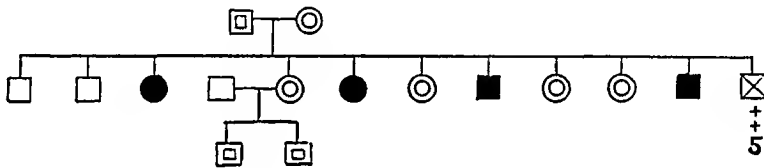


Fig 5—Bucklers' family, showing heredity of central pulverulent cataract

Harman,<sup>30</sup> who described the presence of the cataract in 2 sisters with unaffected parents, Harman did not claim recessiveness in his cases, pointing out only that if traces of the cataract could be found in the relatives of either parent the problem of recessive inheritance would emerge. In order to establish recessive inheritance in Bucklers' pedigree, one must show that both parents were heterozygous in order to produce the anomaly. Considering the rarity of occurrence of this anomaly within the population, the parents should have been close relatives, which was not the case, otherwise mention of it would surely not have been omitted. Recessiveness cannot be excluded, but the incidence is four tenths of the expected, and appearance of the anomaly is very unlikely in random matings of unrelated persons. The probability of dominance cannot be completely discarded, one of the parents may have carried the gene, which did not come to expression.

Analysis shows that in the families reported by Poos and Vogt, respectively, there was unquestionable dominance, and probably also in the case of Bucklers, despite the fact that the latter considered the

29 Bucklers, M. Erbliche Linsentrübungen, in Gutt, A. Handbuch der Erbkrankheiten, Leipzig, Georg Thieme, 1938, p. 126.

30 Harman, N. B. Familial Discoid or Coppock Cataract, Tr. Ophth. Soc. U. Kingdom 30: 29, 1910.



mode of inheritance recessive. The family of Russo<sup>17</sup> is to an even less degree likely to outweigh the claim of recessiveness, this case led to a rather confusing presentation of the question by Bellows. His summary of the hereditary influence is regrettably inaccurate and does not clarify the question at all. He made only two citations—the first, that Nettleship and Ogilvie found nearly 20 affected members within one family, but he did not mention the fact that this family was presented as showing a dominant type of heredity, or even refer to all the other proved instances of dominance. The second concerned the family of Russo, and his conclusion that here there was an apparently mendelian recessive inheritance is the only comment concerning the type of inheritance. Certainly, this kind of presentation does not do justice to the known facts of hereditary transmission, not to mention the circumstance that the assertion of Russo does not hold water in the light of present genetic knowledge.

Russo's family started with 2 affected brothers, the first one married a cousin, the second brother's wife was unrelated. The first

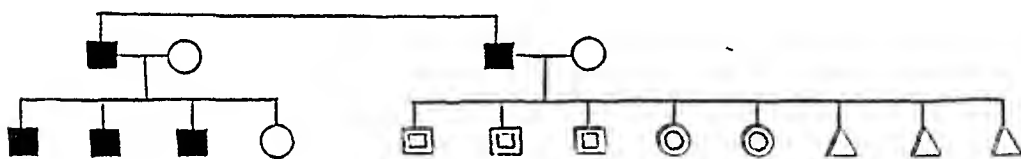


Fig 6—Russo's family, showing heredity of central pulverulent cataract. The triangle means that the sex was not stated.

marriage resulted in 3 affected boys and 1 girl, who refused to be examined (9 pregnancies, 4 living children). The second brother had 8 children, 3 males and 2 females were examined and proved to be unaffected, 3 others (sex not given) were not examined. Russo stated that the family of the first brother would support the conclusion of dominant inheritance, but the negative family pedigree of the second brother proved that the mode of inheritance was not dominant but recessive, without the examination of the family of the second brother the recessiveness would have escaped unobserved, as a false dominant trait. The basis of the conclusion is the fact that the disease appeared only in the family of the first brother, therefore only in a consanguineous union, and must be recessive. Bellows not only accepted the opinion of Russo but, by not presenting any facts concerning the proved dominance in other cases, carried the impression of proved recessiveness by implication.

The dominance of the anomaly in the case of the first brother needs no further elucidation. An autosomal dominant gene, if one parent is normal and the other is a heterozygous affected person, would produce 50 per cent normal and 50 per cent heterozygous affected offspring. In the case of the second brother the first, and valid, objection is that only

5 of the 8 children were examined, therefore the possibility that the 3 unexamined children were affected remains undecided. If 1 person in 100,000 is affected, 6 persons in 1,000 would be heterozygous for the defect. AA, Aa and aa would represent the three types of offspring, and necessarily the Aa type would be present in 3 of 100,000 marriages. Therefore the absence of the anomaly in 5 children of the family of the second brother does not exclude the possibility of dominance, for such a ratio could happen by chance once in 32 similar families. If all the 8 children had been examined and been found free of the defect, this would speak against the possibility of dominance, because, on the basis of the same calculation, 8 normal children would happen by chance only once in 256 similar families (chance of  $A = \frac{1}{2}$ , chance of  $a = \frac{1}{2}$ , probability in case of 5 unaffected children  $(\frac{1}{2})^5 = 1/32$ , probability in case of 8 unaffected children  $(\frac{1}{2})^8 = 1/256$ ). Not only is Russo's conclusion of recessiveness, as carried over by Bellows, unproved, but the family tree is most probably an expression of dominant inheritance.

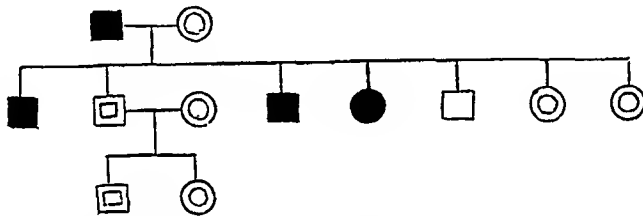


Fig 7—Rados's first family, showing central pulverulent cataract

In the hereditary form of central pulverulent cataract the dominant mode of inheritance is to be expected in accordance with the knowledge of inheritance of various forms of hereditary cataract.

In 2 of the 3 families under my observation the dominant mode of transmission was unquestionable. In the first family, the father had identical small disks, of 2 mm diameter, consisting of typical small dots within the embryonic nucleus, without a second layer of the dots. He was brown haired and had dark gray irises. The corneal refraction was as follows: right eye 43.25 and 43.50 D, axis 85, left eye 43.75 and 44.50 D, axis 105. Vision in the right eye was 15/50, and with a correction of +0.50 D sph  $\subset$  +0.75 D cyl, axis 90 it was 15/20. Vision in the left eye was 15/50, and with a correction of 2.00 D cyl, axis 105, 15/20. He was 63 at the time of his examination. His wife, aged 58, had reddish blond hair, light blue irises and normal lenses, corneal refraction in each eye measured 43.50 D. Seven children were living (4 boys and 3 girls), 6 were examined, the first and third boys and the first girl were affected like the father. All were unmarried with the exception of the second (unaffected) son, whose 2 children were free of the anomaly. The father was the transmitter of the cataract to the second generation, and the affected members not only exhibited a cataract similar to that of the father but showed astigmatism of varying degrees. The oldest boy in the second generation had the same small central opaque disk in both lenses, he had brown hair and blue irises, the corneal refraction measured 40.00 and 41.75 D in the right eye and 41.25 and 41.50 D in the left eye. Vision in the right eye was 15/100, and with a correction of +1.75 D cyl, axis 90,

15/20 in the left eye vision was 15/100, and with a correction of 1.50 D cyl, axis 90, 15/20. The second (unaffected) son was blond with gray irises, corneal refraction in each eye measured 44.25 D, vision was 15/20 in each eye, and 15/15 with a correction of +0.75 D. The third (second affected) son, again, had brown hair and blue irises, the opaque disks in his case had a diameter of approximately 4 mm, filling out the undilated pupil entirely. The morphologic character of the larger disks in his cases was the same as that in the previous cases—minute gray dots surrounded by a lighter halo, without the presence of larger dots or a second ring of dots. Corneal refraction measured 43.25 D in the right eye and 43.25 and 43.50 D in the left eye, vision in the right eye was 15/100 and 15/20 with a correction of +1.75 D sph  $\ominus$  +0.75 D cyl, axis 90, vision in the left

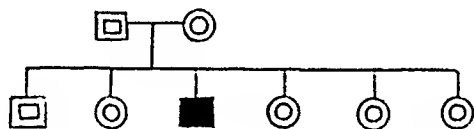


Fig. 8—Rados's second family, with central pulverulent cataract

eye was 15/200, and 15/30 with a correction of +2.75 D sph  $\ominus$  +0.50 D cyl, axis 90. In the case of the first daughter the opacity measured 3.5 mm and was round, with cleancut edges (larger than in the cases of the father and the first affected son and smaller than in the case of the second affected son), she had blond hair and light blue irises, her corneal refraction was 43.50 and 44.75 D in the right eye and 43.00 and 44.50 D in the left eye, vision was 8/200, and with a correction of -6.50 D sph  $\ominus$  -1.0 D cyl, axis 180 it was 15/20, vision in the left eye was 8/200, and with a correction of -5.00 D sph  $\ominus$  -1.25 D cyl axis 180, 15/20. The next in line, a son, could not be examined but allegedly had normal eyes. The fifth and sixth children, both unaffected girls, had blond hair

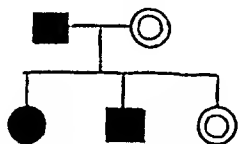


Fig. 9—Rados's third family, with central pulverulent cataract

and light blue irises. The fifth child had a corneal refraction of 42.50 D and visual acuity of 15/30 (15/15 with a correction of +0.75 D in each eye), the sixth child had corneal refraction of 44.75 D in the right eye and 44.25 D in the left eye, and a visual acuity of 15/30 (15/15 with a correction of +0.50 D). All the refractive data were obtained in the first generation with eucatropine and in the second generation with homatropine. The children of the third generation (1 child, 3 years of age) had normal lenses, refractive data could not be obtained because of lack of cooperation. In the second generation the children inherited the cataract together with the corneal astigmatism from the father, the children with clear lenses were free from astigmatism, a defect known to follow the rule of dominance.

In a second family, the father and mother and 6 children (2 boys and 4 girls) were examined, and only 1 child, the second son, was typically affected, the opacity measuring about 2 mm and occupying the embryonic nucleus, without an additional line of dots. The second child, a girl, had normal lenses but showed heterochromia

of the irises, the right iris being brown and the left light blue, with a few white corneal deposits in the lighter-colored eye

In the third family, the father had a small central opaque disk in the embryonic nucleus in each eye, in front of the nucleus toward the posterior layers of the anterior cortex, lay a thick, gray, massive opacity, with diffuse, delicate, stripe-shaped opacities in the anterior and, especially, in the posterior cortex. There were a few angular opacities in each lens. The mother and the youngest girl had clear lenses. The oldest child, a girl, and the second child, a boy, had a similar condition in both eyes, in the case of the girl the associated opacities of the posterior cortex were denser, in the case of the boy, in front of the small central pulverulent cataract, there was a dense pyramidal projection toward the anterior cortex

In the first and third families the trait showed abundant evidence of a dominant mode of inheritance. In the second family, in which a single case was observed in the family, the possibility of mutation, as in all isolated cases, must be considered, the rarity of the gene and the nonconsanguinity of the parents do not permit the conclusion of recessiveness. Rare genes have a small incidence in the population, and the disease assumes an overt form only when the genes conveying the trait are inherited from both parents (heterozygous normal persons). When the character is rare, the chances of this happening are negligibly small, except in cases of consanguinity there is the possibility that two such rare genes are brought together by chance.

The family trees reported in this paper and the literature show that the mode of inheritance is dominant. As I have proved, the recessive inheritance claimed by a few authors cannot be substantiated. The evidence for the dominant mode of inheritance is apparently unanimous in the case of central pulverulent cataract, which is not always the case, as it is known that some anomalies may behave as a dominant in one family and as a recessive in another. Two possible solutions may be offered in explanation of this behavior. First, identical phenotypic diseases are not necessarily identical genotypic deviations. Second, a certain anomaly is dependent on the cooperation of multiple genes, which may be so closely attached to one another in the chromosome that they usually act as a unit but may become separated, a given person might possess only the incomplete set of genes, which would require union with the complementary genes in order to produce the typical anomaly. Therefore the disease might behave as a dominant in one family, before the separation of the genes, and as a recessive in the same family, after the separation took place. The splitting or dissociation of the genes explains the rare cases in which the mode of inheritance of a certain anomaly changes the mode of inheritance within the same family in the course of the successive generations. Central pulverulent cataract does not show such changes of transmission, the so-called recessive inheritance was only suggested, but not proved.

# EFFECT OF GRENZ RAYS ON LEPROUS INFILTRATIONS

## III Response of Lesions of the Anterior Portions of the Eyeball

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AND

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**I**NVOLVEMENT of the eye is one of the most serious complications of leprosy. Opinions differ as to the frequency of occurrence of such involvement. Rogers and Muir<sup>1</sup> found involvement of the eye in 5 to 10 per cent of their patients with lepromatous leprosy. De Silva,<sup>2</sup> as well as Neve,<sup>3</sup> stated that the percentage for this complication was 20 to 25. Chance,<sup>4</sup> in Norway, found ocular involvement in 90 per cent of patients who had lepromatous leprosy and in 75 per cent of patients who had the neural type of leprosy. Borthen<sup>5</sup> reported involvement of the eye in 91.92 per cent of women who had the tuberculous and neural types of leprosy and in 98.33 per cent of men who had these forms of leprosy. Duke-Elder,<sup>6</sup> citing data given by various authors, pointed out that ocular involvement is likely to occur at any time during the course of leprosy.

### GENERAL CONSIDERATIONS

It would appear that in regions in which the body is usually covered with clothes, the face and, consequently, the eyes are involved more frequently than is true in countries in which such covering is not the

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1 Rogers, L., and Muir, E. *Leprosy*, ed 2, Bristol, John Wright & Sons, Ltd, 1940.

2 de Silva, W. H. *Lepra Ophthalmica in Ceylon*, *Ophthalmoscope* 6: 70-76 (Feb.) 1908.

3 Neve, A. *Notes on Ocular Leprosy*, *Brit. M. J.* 1: 1153 (May 12) 1900.

4 Chance, B. *The Ocular Aspect of Leprosy*, *Ann. Ophth.* 25: 432-433 (April) 1916.

5 Borthen, L. *Die Lepra des Auges. Klinische Studien, mit pathologisch-anatomischen Untersuchungen von Dr. H. P. Lie*, Leipzig, Wilhelm Engelmann, 1899.

6 Duke-Elder, W. S. *Text-Book of Ophthalmology*, St. Louis, C. V. Mosby Company, 1938, vol 2, pp 1480-1481.

rule Soto<sup>7</sup> classified ocular complications of leprosy under three categories, according to the mode of formation (1) extensions of leprosy processes situated elsewhere, (2) endogenous foci, carried by way of the blood stream, and (3) extensions proceeding along the nerve trunks

The ocular lesions most commonly encountered in the aforementioned regions consist of lepromas, which as a rule appear temporally on the bulbar conjunctiva close to the limbus as yellowish, gelatinous nodules, from there they tend to invade the cornea. There is a certain superficial resemblance between these nodules and the limbal forms of spring catarrh (vernal conjunctivitis). These infiltrations, as they progress into the deeper layers of the cornea, produce severe visual disturbances. As a rule, the nodules do not remain confined to the bulbar conjunctiva, they are likely to spread from this site to the sclera.

It is this type of ocular lesion in particular that is somewhat amenable to local therapy unless the process has penetrated too far into the eye or—as often happens—the process originates from the ciliary body. The usual treatment of lepromas of the anterior portions of the eyeball consists of the application of solid carbon dioxide, the local injection of various drugs and surgical measures. It might, therefore, be expected that a suitable form of radiant energy might also prove helpful.

#### PREVIOUS THERAPEUTIC INVESTIGATIONS

In previous experiments with irradiation, it was found that cutaneous lepromas were noticeably affected by the grenz rays<sup>8</sup>. In the case of such irradiation of facies leontina and lepromas of the skin of the hands, the results also were fairly good, and local recurrences could be forestalled by adequate doses of the rays<sup>9</sup>.

Before the rays were applied to the eyeball, it was important to know whether grenz rays would be absorbed by the superficial layers of the anterior parts of the eyeball, and, if so, to what degree. It was also important to know whether there was any likelihood of damage

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7 Soto, M. C. Algunas consideraciones sobre el tratamiento de las complicaciones oculares de la lepra, *Rev argent dermatosis* **27** 429-433 (Sept) 1943, Consideraciones clinicas sobre las complicaciones oculares de la lepra, *ibid* **27** 412-422 (Sept) 1943

8 Sagher, F. Effect of Grenz Rays on Leprous Infiltrations. Report of an Attempt to Influence Leprous Infiltrations by Roentgen Rays of Long Wavelength, *Arch Dermat & Syph* **50** 311-314 (Nov) 1944

9 Sagher, F, and Franco, S. The Effect of Grenz Rays on Leprous Infiltration. II. Report of an Attempt to Influence Facies Leontina and Perforating Ulcer of the Foot by Roentgen Rays of Long Wavelength, *Dermatologica* **93** 272-294 1946

to the lens and deeper structures. In earlier experiments on rabbits and on excised human eyes, it was ascertained that between 89 and 97 per cent of Grenz rays were absorbed by the human cornea and that between 88 and 94 per cent of the rays were absorbed by the sclera<sup>10</sup>. On exposure of the cornea and aqueous humor to these rays, absorption was between 97 and 99 per cent, so that practically the question of damage to the deeper structures did not arise.

Furthermore, it had to be decided beforehand whether or not large doses, such as are necessary for the treatment of lepromas, would damage the eyeball. Experience in this regard is not extensive. Pfeiffer<sup>11</sup> reported on 4 patients who had received four series of five treatments, each treatment consisting of 452 r, in a total of five sittings, with rest intervals of two weeks. He described "remarkable reactions of the conjunctiva and the episcleritic tissue". Krasso,<sup>12</sup> experimenting on animals, reported that ocular damage occurred only after 7,830 r had been administered, the reaction, although gradually subsiding, was still ascertainable histologically in the cornea when the eye was excised after two hundred and twenty-four days. Bucky<sup>13</sup> recommended a dose of from 1,500 to 2,500 r for the treatment of superficial tumors of the eye.

On the basis of experience gained in irradiation of lepromas of the skin, it follows that doses of less than 400 r have no considerable effect, and that to achieve satisfactory results the individual doses should be between 600 and 1,000 r. In some cases, however, administration of doses within this range was followed by erythema and scaling, and it was questionable whether the eye would tolerate this kind of treatment. In the first 3 patients in our series, therefore, it was chiefly the tolerance and the reactions of the cornea and conjunctiva to such doses that had to be studied.

In the first patient, a lepromatous eye, practically blind from early childhood, was irradiated. In the second patient a completely blind lepromatous eye was irradiated. In the third patient, an eye was treated the cornea of which was completely covered with a lepromatous pannus. Only after these experiments had proved innocuous, and even encouraging, were additional patients treated. These additional

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10 Sagher, F, and Sagher, E. Absorption of Infra-Roentgen (Bucky) Rays of Various Qualities by the Anterior Portions of the Eyeball, *Arch Ophth* **30** 43-53 (July) 1943.

11 Pfeiffer, R. L. Treatment of Diseases of the Eye with Grenz Rays, *Arch Ophth* **21** 976-986 (June) 1939.

12 Krasso, I. Experimentelles und histologisches über den Einfluss einer einmaligen Bestrahlung mit Bucky's Grenzstrahlen auf das gesunde Kaninchenauge, *Ztschr f Augenh* **70** 237-256 (Feb) 1930.

13 Bucky, G. Grenz Ray Therapy, New York, The Macmillan Company, 1929.

patients were 3 persons whose vision was fairly good or good, they, similarly, received irradiation therapy

#### TREATMENT

The eyes were anesthetized by the instillation of a 4 per cent solution of cocaine hydrochloride, the eyelids were opened as wide as possible with Desmarres' retractors. The patient was then asked to glance in such a way that the leproma appeared in the middle of the palpebral fissure. The irradiation tube was adjusted vertical to the leproma at a distance of 10 cm. Tears, likely to absorb a considerable portion of the rays, were swabbed away with cotton wool. The lid retractors were placed in such a way as to cover the eyelids with their broad portions, since otherwise considerable erythema of the skin of the eyelids might result. A bismuth paste was applied to those portions of the skin which remained uncovered.

#### REPORT OF CASES

CASE 1—A woman aged 39 presented lepromatous leprosy with all its clinical and bacteriologic characteristics. Since the end of 1941 she had had a limbal leproma in her left eye. Treatment with solid carbon dioxide, which she had previously received several times, had had no appreciable effect. For the three months prior to the time we saw her the patient had remained without treatment. Examination on March 16, 1941 disclosed no specific changes in the eyes. The left eye presented corneal opacities, which had been there since the patient's earliest childhood. The fundus was normal. The only symptom was a certain immobility of the pupils, they did not dilate after the application of homatropine. On Dec 8, 1941, the patient returned because of superficial opacity of the entire left cornea and a leproma on the temporal side, occupying a third of the cornea and probably penetrating through all its layers. There was occlusion of the pupil as a sequel of cyclitis. The patient could count her fingers only at a distance of 59 inches (15 meters). She complained of attacks of severe pain in her eyes. Nothing abnormal was noted in the right eye.

On December 8, 1941, 1,200 r was administered to the left eye. The factors were 170 volts, 10 milliamperes, approximately 6 kilovolts, which is equivalent to a half value layer of 0.021 mm of aluminum, distance, about 4 inches (10 cm), rate of exposure, 375 r per minute. On Jan 15, 1942, 1,200 r was administered. No changes were noticeable thereafter, although the patient reported that the pain had subsided. On February 5, 1,200 r was administered. Occasionally slight irritation of the eye was noted. On March 10, 2,000 r was administered. Intense conjunctival injection was seen. The patient had been free from pain all the time. On April 23, 1,200 r was administered. On June 1, it was seen that the leproma had become definitely flatter. Dilated blood vessels were now seen surrounding the lesion. On July 7, 1,200 r was given, on August 4 this dose was repeated, followed by the same dose on September 3. The total dose was 11,600 r.

On Nov 15, 1942, biopsy of a specimen of tissue from the site of the leproma showed, beneath the mucous membrane, small lesions containing acid-fast bacilli, partly isolated, partly in groups.



The patient was kept under constant observation. When she was last examined, on Oct 2, 1945, the left eye presented a grayish white, completely flat opacity at the former site of the leproma, with small, degenerative inclusions. Behind the radially arranged deposits, streaks were seen which resembled folds of the lamina elastica posterior. The anterior chamber was deep, there was partial atrophy of the iris. The pupil was occluded by a dense membrane.

The patient was able to count her fingers at about 20 inches (0.5 meter). In the right eye a slight, whitish protuberance with enlarged blood vessels was present at the limbus, it extended from 9 to 2 o'clock. Toward the cornea the borderline of this protuberance was indistinct. On the temporal side, the cornea contained a slight, subepithelial opacity, the iris showed small, yellow nodules (nodular iritis). The lens was normal.

CASE 2—A girl aged 19 had had lepromatous leprosy for four years prior to the time of her admission. Examination of the eyes disclosed not too dense superficial keratitis in the right eye, with a moderate number of keratic precipitates. The upper and nasal part of the iris showed a large leproma, temporally, small white nodules were seen. Occlusion of the pupil was noted. The patient could distinguish hand movements. The fundus was invisible.



Right eye of the patient in case 2, after irradiation, as compared with the left eye, which was not treated. The left eye is distinctly inflamed. The cornea of the left eye is more opaque than the cornea of the right eye.

Dense keratitis, with abundant keratic precipitates, was present in the left eye. A few isolated nodules were apparent in the iris. Posterior synechia, not clearly visible because of corneal opacity, was detected. The patient could count fingers at about 10 feet (3 meters). She complained of severe pain and of lacrimation.

Between Jan 15 and Aug 4, 1942 the patient received irradiation of the right eye with doses of between 1,200 and 1,500 r, to a total of 7,800 r. The factors were 210 volts, 5 milliamperes, 14 kilovolts, filtered through 0.01 mm of cellophane, which is equivalent to a half value layer of 0.031 mm of aluminum, distance, 10 cm, rate of exposure, 462 r per minute. Treatments were given at intervals of four to six weeks.

After the patient's second sitting the pain subsided. Occasionally there was a slight erythematous reaction. After the course of treatment had been completed, there was no evidence of irritation, whereas the untreated eye was distinctly inflamed (figure). The left cornea at this time was definitely more nearly opaque than the right one.

The patient was under observation until Jan 18, 1944. The condition of the affected eye remained stationary.

Examination on Jan 18, 1944 showed that the right eye was not irritated. In the center of the cornea a superficial opacity was seen, in the periphery grayish dots and deep blood vessels were evident. The iris showed no changes in the condition seen at previous examinations. Occlusion of the pupil was noted. There was no perception of light. The left eye, similarly, was not irritated, but there was opacity of the cornea, with deep and superficial blood vessels. No details of the iris were discernible because of the dense opacity. There was no perception of light.

The patient died in October 1945, from complications of the rapidly progressing leprosy.

CASE 3—A woman aged 27 had had lepromatous leprosy for nine years prior to the time we saw her. At examination on Feb 22, 1944 (prior to irradiation therapy) a leukoma was seen to occupy half the cornea. The rest of the cornea was opaque. On the lower portion of the limbus a small leproma was surrounded by dilated blood vessels. On examination with the slit lamp the nasal side of the cornea seemed to be slightly clearer, otherwise, deep blood vessels were visible in the whole area. The patient could count fingers near the eye. The fundus was not visible. Examination of the right eye with the slit lamp showed that the entire cornea was opaque, with superficial and deep blood vessels evident to a somewhat less degree on the nasal side. The nerve fibers were thickened. The iris, lens and fundus were normal. Vision was 5/9.

Irradiation of the left eye was started on Feb 23, 1944. The factors were 210 volts, 10 milliamperes, 10 kilovolts, which is equivalent to a half value layer of 0.027 mm of aluminum, distance, 10 cm; rate of exposure, 660 r per minute. On March 21, 1944, 800 r was administered. The leproma on the lower portion of the limbus presented a central depression, which stained with fluorescein. There was no irritation. On May 10, 1944, 700 r was administered. The leproma was flatter and did not stain with fluorescein. Between May 30 and Oct 23, 1944, five more irradiations, with doses of 600 to 800 r each, were carried out. The total dose administered (February to October) amounted to 5,500 r.

From time to time the patient reported for examination, at the last time, on May 1, 1946, she was found to be in a very poor general condition because of the rapid progression of the lepromatous process all over her body.

A total leukoma was seen in the left eye, and a new leproma surrounding the cornea had appeared, leaving the area which had been exposed to treatment with the grenz rays definitely flatter.

A large leproma was spreading over the cornea of the right eye, only the upper nasal portion being still intact.

CASE 4—A woman aged 25 had had lepromatous leprosy, with extensive bilateral involvement of the ulnar nerve, for twelve years prior to the time we saw her. Examination of the left eye (prior to irradiation treatment) revealed a leproma on the temporal part of the limbus, extending over approximately one-half the cornea. That part of the cornea which lay outside the leproma was clear. The leproma was elevated above the plane of the cornea by approximately 3 to 5 mm. The patient could count fingers at about 11 feet (3.5 meters). Cyclitis, with yellow patches in the iris, was present. Examination of the fundus disclosed anterior choroiditis. There were no changes in the right eye, vision was 5/11.

In the period between Oct 28, 1943 and July 24, 1944 the patient received a total of 8,000 r, in doses of 800 r each, at intervals of four to six weeks. The irradiation factors were the same as those employed in case 3.

Before irradiation was started, a specimen for biopsy was taken from the area occupied by the leproma. Histologically, no granulation tissue was observed, because the section was too superficial, consisting almost exclusively of epithelium of the mucous membrane. *Mycobacterium leprae* was not demonstrated.

Half a year after treatment had been started the leproma began to be definitely flatter, that is, after a total of about 4,800 r had been administered.

The patient was under observation all the time. At the last examination, on May 1, 1946, the left eye was seen to contain, instead of the leproma, a leukoma, with dilated blood vessels. Outside the area of the leukoma the cornea had a normal appearance. The iris was not irritated. The lens was normal. The patient could count fingers at about 6 feet (1.5 meters).

The right eye contained a slight corneal opacity, central choroiditis was evident.

**CASE 5**—A girl aged 18 had had lepromatous leprosy for six years prior to her coming to consult us. She complained of pain in both eyes.

Examination of the right eye (prior to irradiation treatment) revealed infiltration of the bulbar conjunctiva at a distance of approximately 2 mm from the upper part of the limbus. Deep opacity of the cornea extended tongue-like, from above downward, almost to the center of the cornea. From all sides superficial vessels were seen proceeding toward the cornea, leaving only the center intact. The iris, lens and fundus were normal. Vision was 5/15.

Infiltration of the bulbar conjunctiva of the left eye extended from 11 to 5 o'clock, with pronounced inflammation. In the upper sector of the cornea a leproma was observed extending tongue-like down to the center. The iris, lens and fundus were normal. Vision was 5/30.

In the period from April 18 to Nov 30, 1944, the leproma of the left eye was irradiated, the patient receiving a total of 7,400 r, in doses of 800 to 1,000 r each. The factors were the same as those used in case 3. In spite of the irradiation, the leproma continued to grow, while, at the same time, numerous fresh nodules and infiltrations developed all over the body, including the face.

The patient was under observation during the entire period of treatment. At the last examination, on May 1, 1946, a leproma, approximately 4 mm in height, was observed on the lower portion of the limbus (from 10 to 4 o'clock) in the left eye, with infiltration of the entire cornea, leaving a slightly clearer area in the center. At the site at which the leproma had been only binary injection could be noticed.

The right eye exhibited a ring-shaped leproma at the limbus, in the upper portion of the cornea was a deep, gray opacity.

**CASE 6**—A woman aged 33 had had lepromatous leprosy for five years prior to the time we saw her. She complained of constant pain in her eyes.

Examination of the right eye (prior to irradiation treatment) disclosed a leproma of the conjunctiva on the temporal portion of the limbus, encroaching 2 mm on the cornea. The superficial corneal layer was transparent, the deeper layers were infiltrated with deep blood vessels. The leproma was elevated above the plane of the cornea by approximately 2 mm. In the left eye the same conditions were seen as those in the right eye, except that the leproma was slightly smaller,

encroaching on the cornea only 1 mm and elevated approximately 1 mm. Vision in both eyes was 5/7. The pupils were not exactly round, but the iris, lens and fundus did not present anything abnormal.

Grenz ray therapy was confined to the leproma of the right eye, which had the more extensive involvement. In the period from Feb. 23, 1944 to Jan. 1, 1945, a total of 9,100 r was administered, the patient receiving doses of 700 to 1,000 r at a time. The factors were the same as those utilized in case 3.

After the administration of a total of 4,300 r, the leproma became definitely flatter. The patient was under observation during the entire period of treatment. At the last examination, on May 1, 1946, the right eye was seen to contain a leproma on the temporal side of the cornea, this leproma had become flattened but was still slightly brownish opaque. In the lower sector were a few isolated blood vessels, at one place a large blood vessel was seen to penetrate into the conjunctiva, which appeared to be normal. The opaque area of the cornea was approximately 1.5 cm in diameter. The left eye, which had not been irradiated, exhibited between 5 and 9 o'clock a broad prominence, about 3 or 3.5 mm wide, overhanging the limbus so as to form a furrow. The adjacent portion of the cornea contained a band-shaped, white opacity, between 1 and 1.5 mm wide. Pain was also more intense in the left eye than in the right eye. The lens was normal. Vision was 5/8.

*Comment*—In principle, only one eye of a patient was irradiated, usually the more severely affected one, the other eye serving as a control. The patient in case 1 had a leproma in the left eye, which eye had been amblyopic from childhood as a result of corneal scars. Damage that might be caused by irradiation could not, therefore, have been of any consequence. Doses of 1,200 r elicited no reaction except for an occasional slight irritation, which persisted for one day to two days. After exposure to still larger doses, however, all patients reported intense irritation, with a sensation of burning and occasional slight photophobia. Tolerance was satisfactory if doses did not exceed 1,200 r and were administered at intervals of four to six weeks. In case 1 the leproma disappeared completely, leaving a scar. During a follow-up period of four years no recurrence was noted at this site, and no changes were observed in the inner structures of the eye. The untreated eye, on the other hand, showed rapid progression of the leprous process concomitant with the advance of the cutaneous lesions all over the body. For the patient herself, it was particularly important that pain had been relieved during the entire period of treatment, whereas previously she had had frequent attacks of violent pain.

In case 2 the patient had been selected for the purpose only of ascertaining the tolerance of the eyeball to very large doses, since it was recognized that she had superficial keratitis, with occlusion of the pupil. That is, the eye was already blind, so that there could be no question of damage to vision with the procedure. The tolerance was satisfactory when doses of 1,200 r were employed, whereas violent reactions were elicited with doses of 1,500 r. In this case, too, the

analgesic effect was an outstanding feature, an aspect that Pfeiffer<sup>11</sup> emphasized in his therapeutic investigations. Although pain disappeared completely from the treated eye, it persisted with undiminished severity in the untreated one. Some degree of improvement in the keratitic process was even noted, the cornea becoming slightly clearer and inflammation subsiding—an effect that is clearly noticeable in the figure.

The patient in case 3 presented severe superficial, as well as deep, opacities of the cornea, with a leproma of the limbus and an ulcer in the lower sector. After irradiation the leproma became flatter, whereas the cornea itself was unchanged.

The patient in case 4 had a leproma at the temporal edge of the cornea of the left eye, this leproma extended as far as the pupil, thus seriously interfering with vision, so that the patient was able to count fingers no closer than about 11 feet (3.5 meters). After she had received a total of 8,000 r, the leproma completely disappeared, leaving a white scar. During the entire follow-up period, extending over two and a half years, no corneal or lenticular changes were noted, and the leproma did not recur. Vision remained unchanged, for all practical purposes. During this period, however, the originally unaffected right eye became involved.

In case 5, lepromas were present not only in the eyes but all over the body, and the number was rapidly increasing. The patient's condition was deteriorating rapidly. In this case, irradiation seemed to exert an adverse effect. At the site of irradiation no noticeable changes occurred, whereas in the neighboring parts of the eyeball new lepromas appeared and developed rapidly.

The patient in case 6 eventually presented slowly growing lepromas in both eyes. These lesions uniformly advanced over the limbus, the lesion in the right eye being slightly larger than that in the left eye. Vision was 5/7 in each eye. Irradiation was, therefore, confined to the right eye, in which the leproma was larger than the leproma in the left eye, at the end of the treatment it was definitely less elevated. During the same period new lesions developed all over the patient's body. Since, however, the leproma in the untreated eye was developing only slowly, irradiation was not continued up to a maximal total dose. During a period of two and a quarter years, vision, as well as the inner structures of the eye, remained unaffected.

#### QUALITY AND DOSAGE OF THE RAYS

Various grades of "hardness" of the rays were employed. In case 1 grenz rays of long wavelength ("soft rays") were applied, that is, the voltage was 6 kilovolts, which is equivalent to a half value layer of 0.021 mm of aluminum. It was established that when the rays were used the cornea absorbed 95 per cent of them, the cornea and the

aqueous humor together probably absorb 100 per cent of them, so that the danger of damage to the lens is practically nonexistent. In the second case, the rays of short wavelength ("hard rays") were purposely chosen, that is, the voltage was 14 kilovolts, which is equivalent to a half value layer of 0.031 mm of aluminum. This was achieved by the insertion of a cellophane filter corresponding to 0.01 mm of aluminum.

In the remaining cases the rays used were of medium quality, that is, voltage was 10 kilovolts, equivalent to a half value layer of 0.027 mm of aluminum. When doses up to 10,000 r were used, the quantities of rays penetrating the cornea or sclera and the aqueous humor were insufficient to cause damage to the lens or deeper structures of the eye. This could be confirmed in our series, so far as the condition of the cornea permitted us to examine the interior of the eye. The periods of observation, starting from the first irradiation, extended up to four years.

For purposes of comparison, in 1 case an area of skin 2 by 2 cm in diameter was exposed to 800 r of the same type of rays as those to which the eye was simultaneously exposed. Although on the next day the eye showed only slight redness and during the subsequent weeks no reaction at all, waves of erythema developed on the skin to such a degree that even after four weeks scaling was still in progress, and as late as eight months later delicate pigmentation was still noticeable.

From this investigation it clearly follows that the reaction of the eye to exposure to grenz rays is far less intense than that of the skin. Since the erythematous reaction of the skin is of a vascular nature, it is understandable that the cornea cannot possibly show this sort of response.

Although the studies reported in the foregoing portion of the text prove that lepromas of the anterior portions of the eyeball cannot be affected by grenz rays, no definite therapeutic conclusions can be drawn, in view of the small number of observations.

#### SUMMARY

Grenz rays were applied to lepromatous changes in the anterior segments of the eyeball in 6 patients. Since it was obvious, on the basis of experience with irradiation of the skin, that only large doses would be able to produce an effect, 3 practically sightless eyes were chosen for exposure to these rays. In all 3 patients the lepromas undoubtedly became reduced in size or disappeared completely.

When the grenz rays were employed on the eyes of 3 additional patients which presented lepromas with fairly good vision, 2 eyes

exhibited a favorable response, whereas in the third the lepromatous part which was irradiated became quiescent, or even slightly flatter, while the surrounding parts presented rapid growth of new lepromas

The voltage of the rays used ranged from 6 to 14 kilovolts, which is equivalent to half value layers of 0.021 to 0.031 mm of aluminum. The most effective doses applied at one sitting were from 700 to 1,200 r, the total amount varying from 5,500 to 11,600 r.

These large doses could be applied safely to the external tissues of the eye because the sensitivity of such tissues to rays is lower than that of the skin.

No damage to the cornea, lens or deeper structures of the eye was noted, so far as this could be determined on the basis of observations extending over a period of between two and four years.

Dr H J Stern, assistant in the Department of Ophthalmology of the Rothschild-Hadassah University Hospital, took an active part in these studies before joining the army. Dr J Landau, assistant in the same department, aided in the study.

# PATHOLOGIC STUDY OF OCULAR LESIONS DUE TO LEWISITE ( $\beta$ -CHLOROVINYLDICHLOROARSINE)

Changes With and Without BAL (2,3-Dimercaptopropanol) Therapy

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IN STUDYING the pathologic changes produced by various war gases, it became apparent that certain histologic events were common to all. All eyes exposed to severe burns with mustard gas (2-chloroethyl sulfide),<sup>1</sup> lewisite ( $\beta$ -chlorovinylchloroarsine)<sup>2</sup> and nitrogen mustards ( $\beta$ -chloroethylamine)<sup>3</sup> showed the following alterations:

- 1 Epithelial changes, followed by loss of epithelium
- 2 Endothelial changes, followed by loss of endothelium
- 3 Alteration of stromal cells, leading to death of the cell, disappearance of stromal nuclei and, eventually, some loss of stromal substance
- 4 Edema of the corneal stroma
- 5 Cellular infiltration of the cornea first with polymorphonuclear leukocytes and later with lymphocytes and large mononuclear cells
- 6 Vascularization of the cornea

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From the Department of Ophthalmology of the University of Pennsylvania Hospital

The work described in this paper was done under a contract recommended by the Committee on Medical Research, between the office of Scientific Research and Development and the University of Pennsylvania

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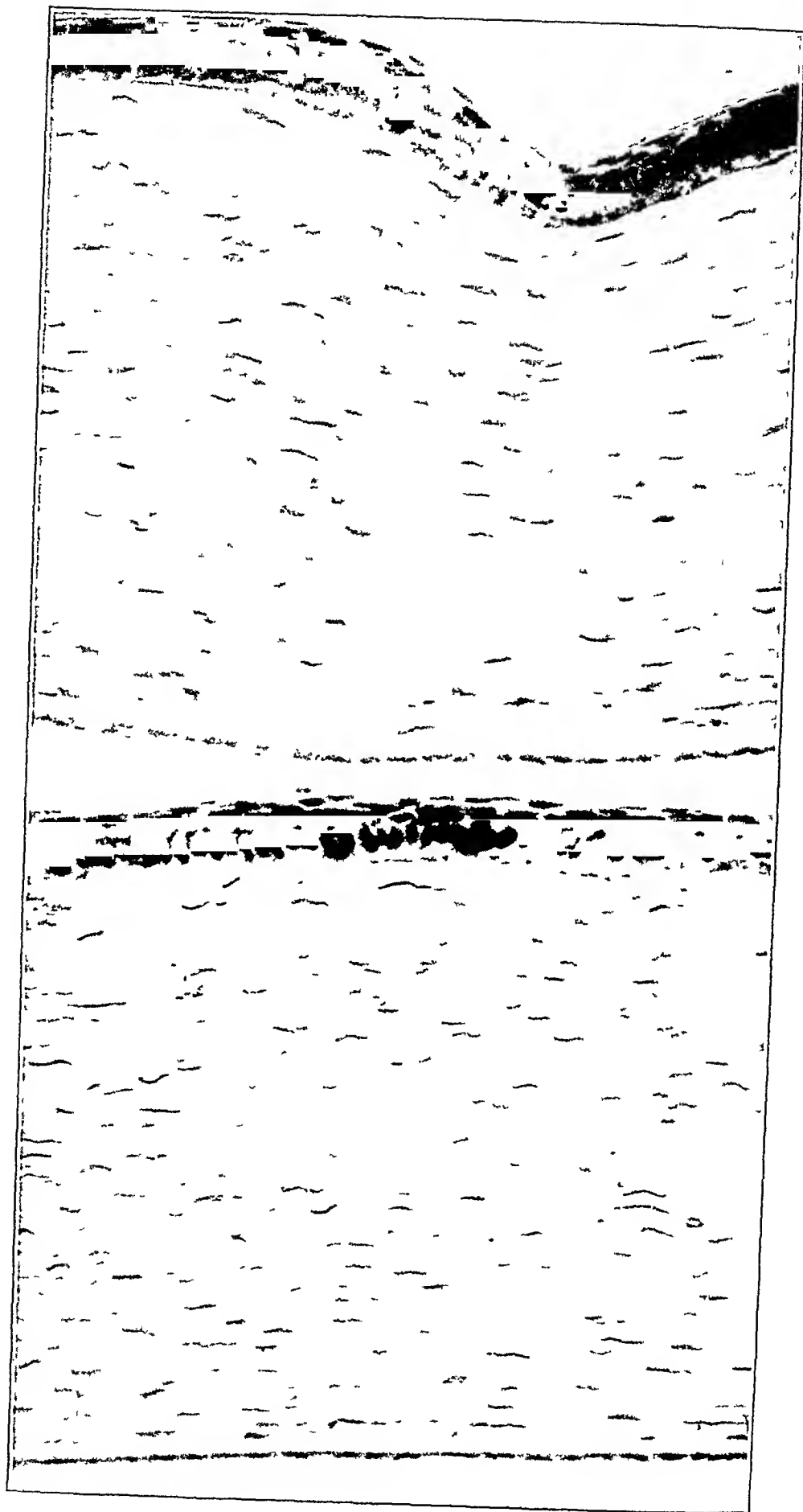


Fig 1—Corneas of untreated (above) and treated eyes one hour after burning with 0.4 mg of lewisite ( $\beta$ -chlorovinyl-dichloroarsine). The treated eye received a 5 per cent solution of BAL (2,3-dimercaptopropanol) two minutes after burning. Hematoxylin-eosin stain, magnification 330

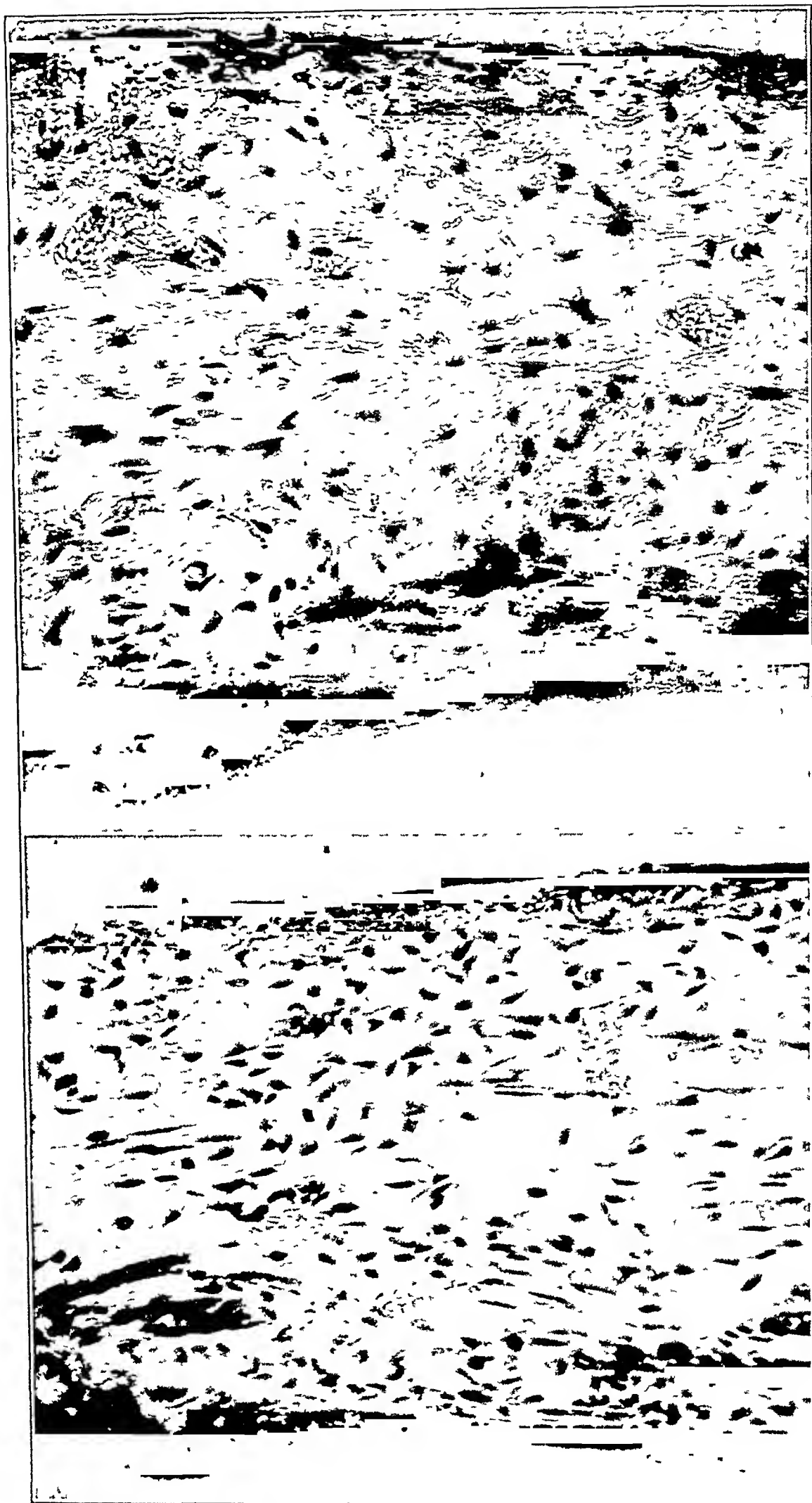


Fig 2—Iris of untreated (above) and treated eyes one hour after burning with 0.4 mg of lewisite. Hematoxylin-eosin stain, magnification, 330

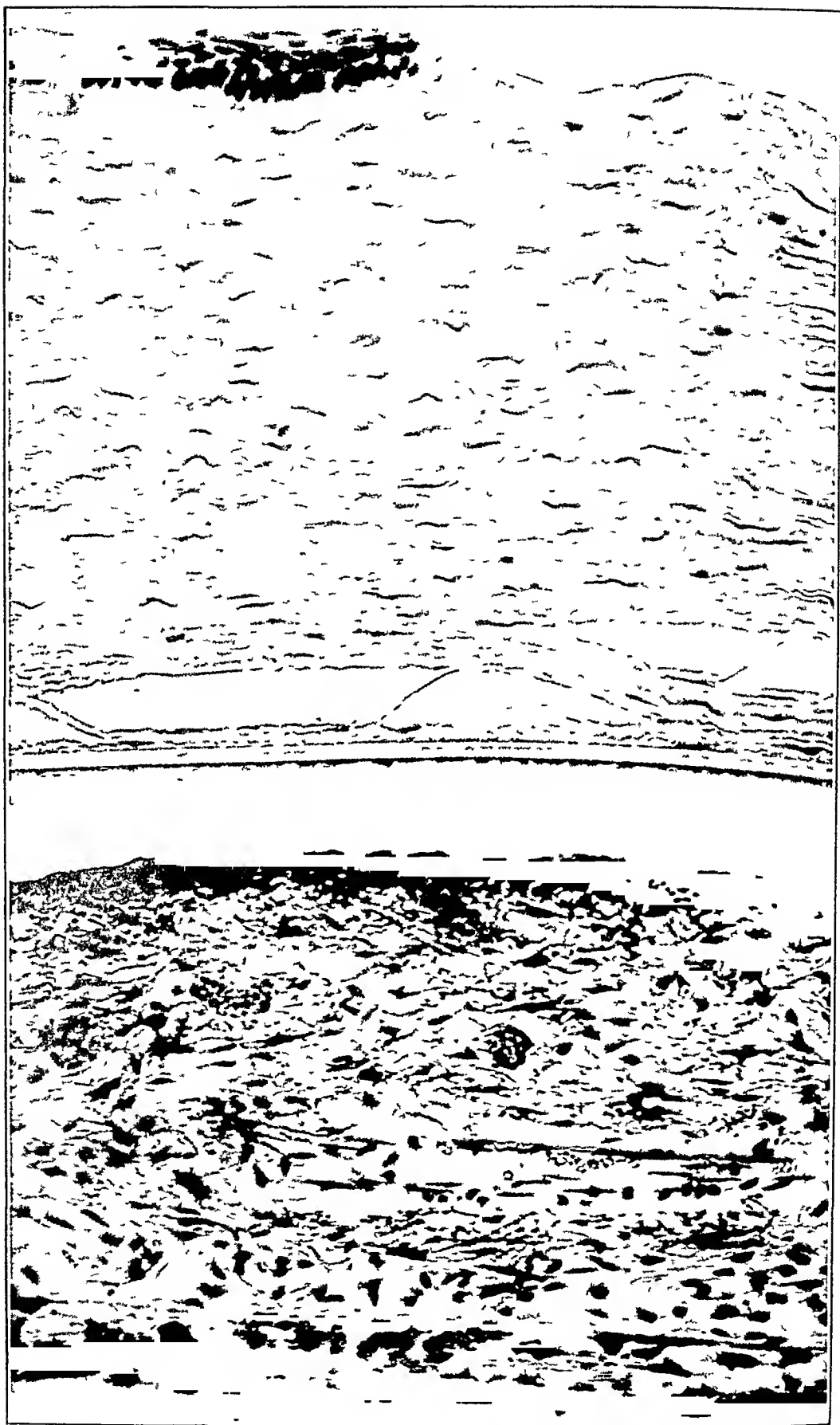


Fig 3—Cornea and iris of an untreated eye six hours after exposure to lewisite (0.4 mg) Hematoxylin-eosin stain, magnification, 330

7 Changes in the iris and ciliary body, consisting chiefly of congestion, cellular infiltration and dispersion of pigment

8 Alterations of the anterior chamber, consisting of deposition of serum and fibrin and cellular infiltration

9 Lenticular changes, ranging from vacuolation to permanent opacification

10 Reparative processes, consisting of newly formed capillaries and fibroblastic tissue

11 Evidences of secondary infection

These histologic events varied in extent in the case of each of the vesicant gases, depending on the following factors (1) amount of vesicant agent and length of exposure, (2) toxicity of the individual gas (i.e., the severity of the changes will vary with the same concentration and time of exposure [C T] of the different gases), (3) length of time elapsing between exposure of the eye and enucleation. In the case of certain gases these changes occurred earlier than in others.

Detailed histologic studies were made of the course of ocular lesions due to lewisite burns in rabbits. These studies were performed on eyes burned by standard technics. Liquid lewisite, 0.4 mg, was delivered by microsyringe to the superior limbus, and the lids were allowed to close immediately. The two eyes of each rabbit were burned with the same dose of lewisite. One eye of each rabbit was treated with 5 per cent BAL in ethylene glycol two minutes after burning. The eyes were enucleated fifteen minutes, one hour, six hours, twelve hours, two days, three days, five days, ten days and fourteen days after exposure. All eyes were fixed in a dilute solution of formaldehyde U.S.P. and prepared for histologic study by the pyroxylin technic. The hematoxylin-eosin stain was used.

#### RESULTS OF HISTOLOGIC STUDY OF UNTREATED EYES

Within ten to fifteen minutes after exposure a definite histologic change could be noted in the cornea (figs 1 and 2). This consisted of swelling of the epithelium with separation from the underlying stroma, representing early edema. During the first hour the process progressed, the epithelium was lost over some areas and showed edema of the basal cells with detachment in others. The fibers of the stroma were separated, and there were vacuolated areas about some stromal nuclei. These changes were indicative also of increasing corneal edema. A fine granular exudate appeared in the anterior chamber. The vessels of the iris and the ciliary body became slightly congested. The conjunctival vessels also were congested, and red blood cells and fibrinous exudate could be seen to have escaped into the conjunctival tissues.

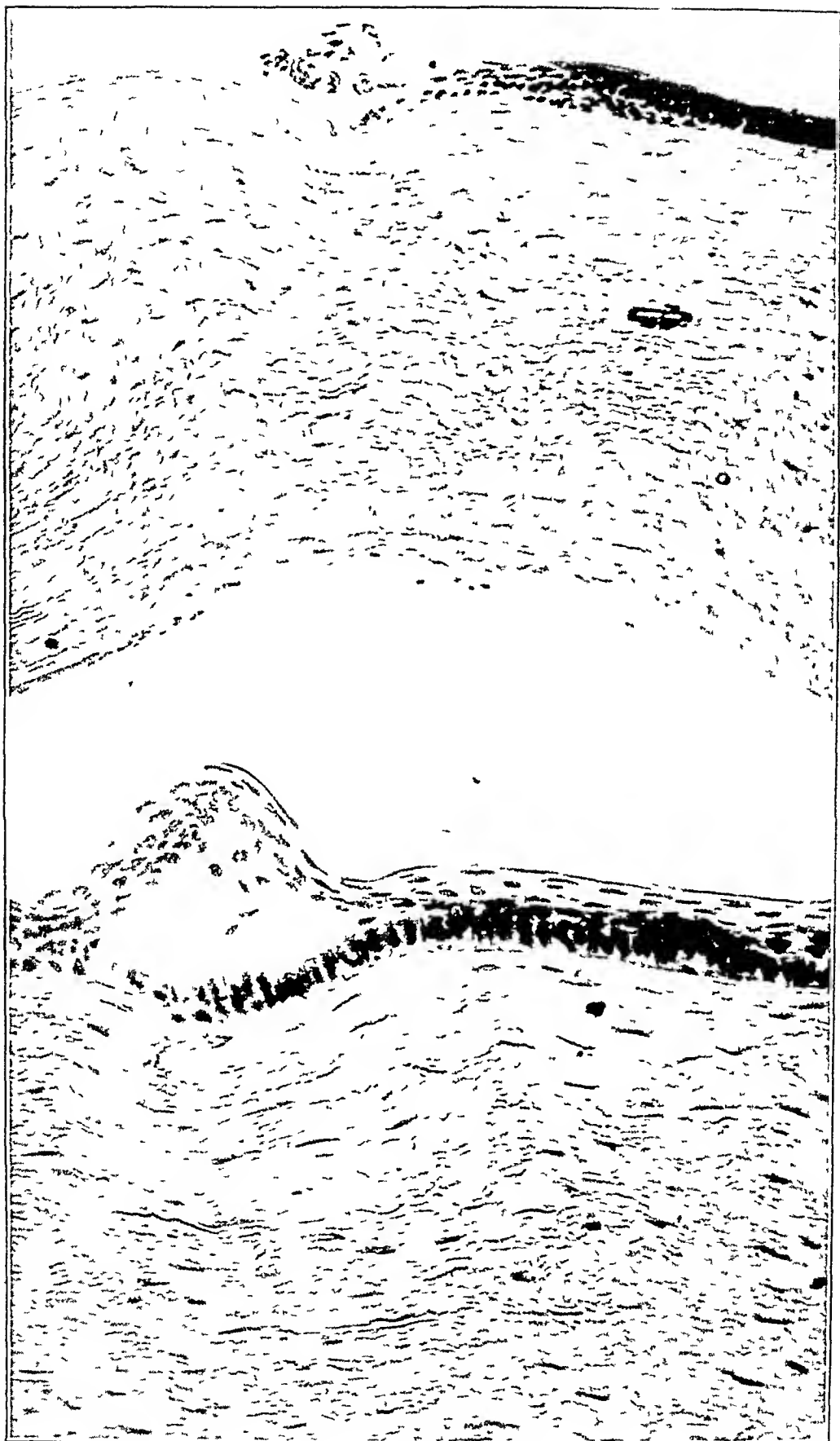


Fig 4—Corneas of untreated (above) and treated eyes six hours after exposure to lewisite (0.4 mg) Hematoxylin-eosin stain, magnification of untreated cornea, 170 of treated cornea, 330

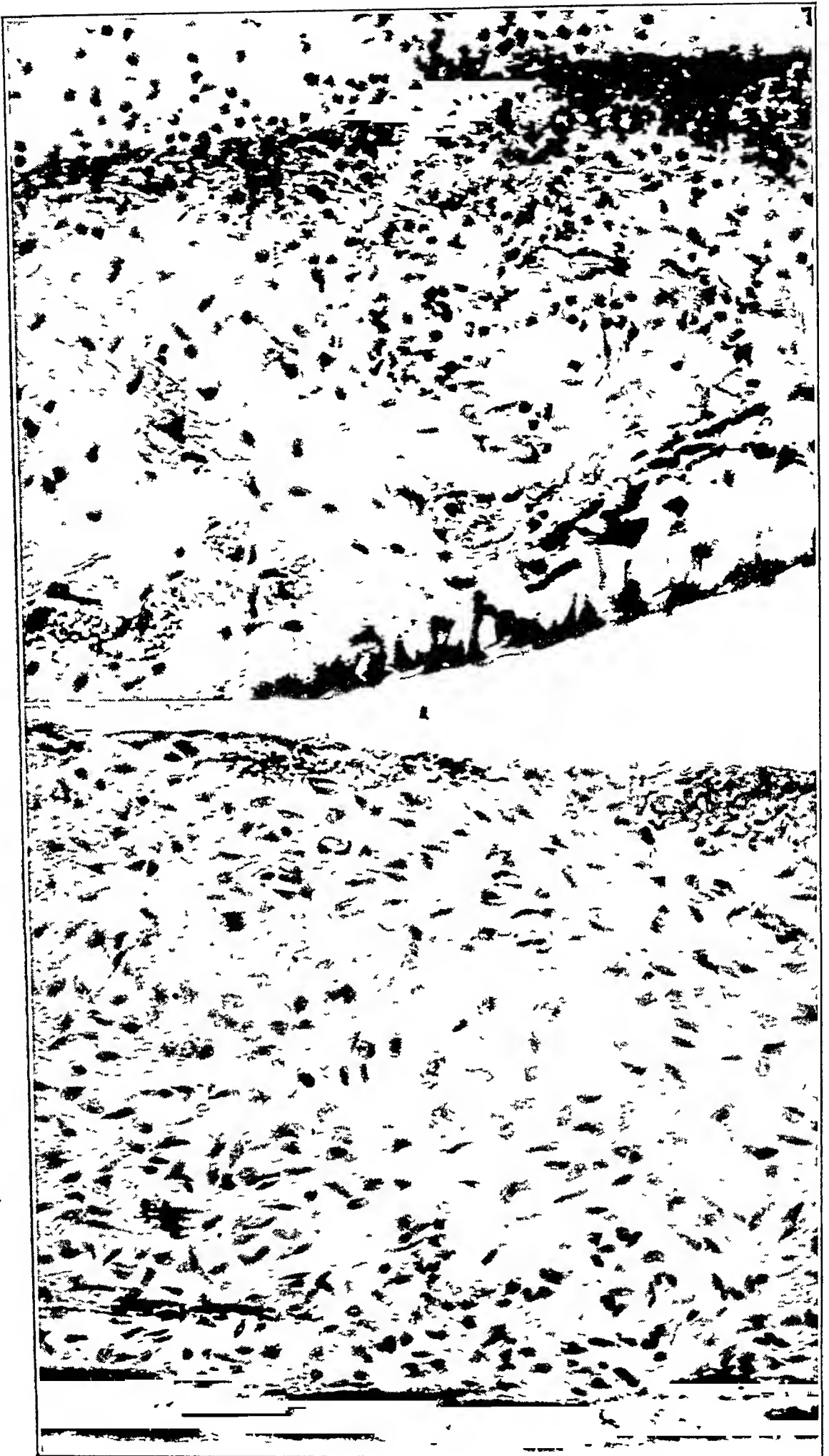


Fig 5—Iris of untreated (above) and treated eyes six hours after exposure to lewisite (0.4 mg) Hematoxylin-eosin stain, magnification, 330

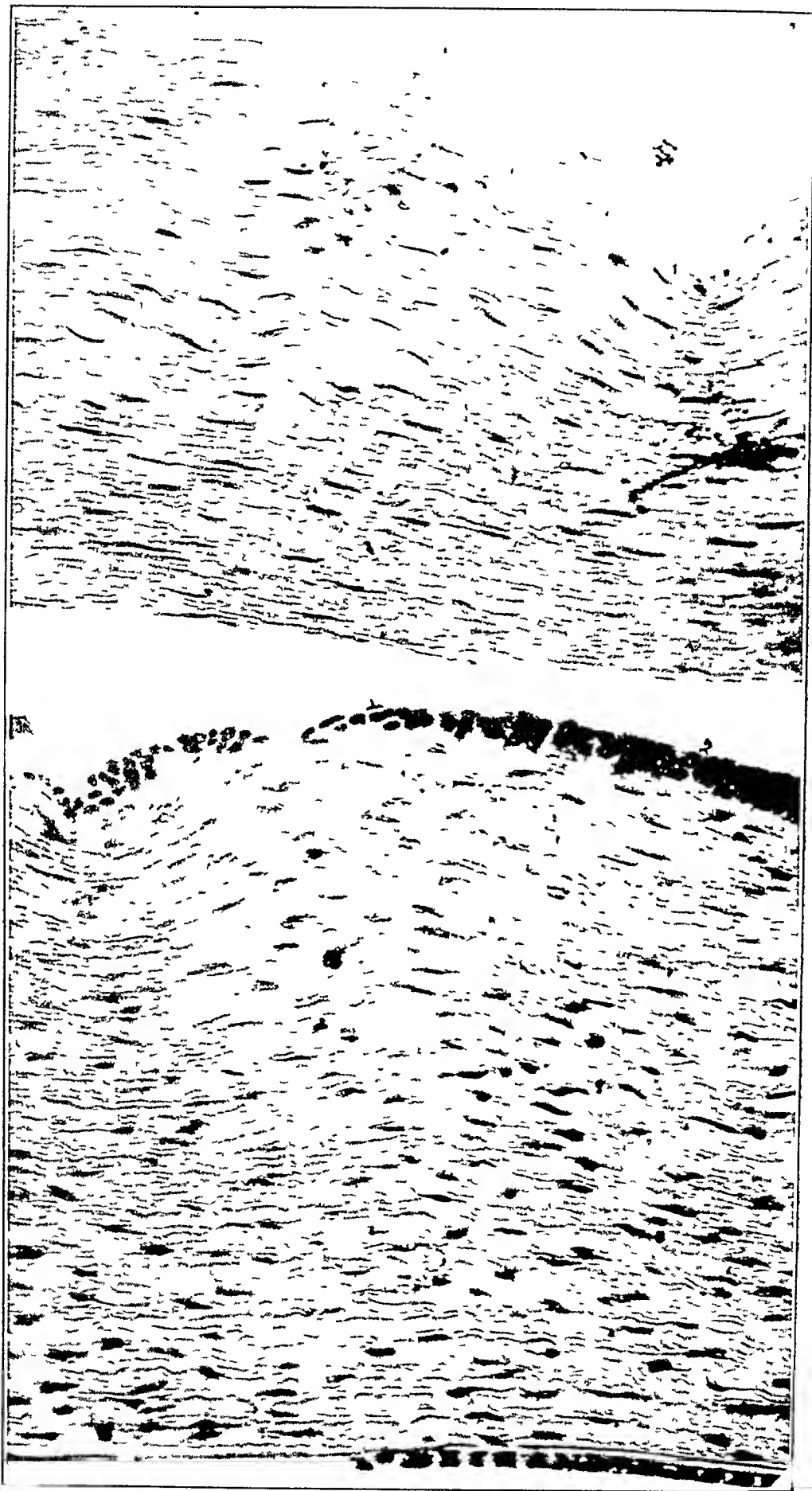


Fig 6—Corneas of untreated (above) and treated eyes twelve hours after exposure to lewisite (0.4 mg) Hematoxylin-eosin stain, magnification, 330

At the end of six hours prominent pathologic changes had appeared in the whole anterior segment of the eye. The epithelium had entirely disappeared from most areas of the cornea. The conjunctiva showed considerable edema and extensive infiltration with polymorphonuclear leukocytes. In the stroma the number of nuclei was reduced, and the staining of all stroma was less than normal. Descemet's membrane was present, but the endothelium was partly lost. A scanty exudate containing polymorphonuclear leukocytes was observed in the angle of the anterior chamber and on the anterior surface of the iris. The iris and ciliary body showed edema, congestion and an occasional polymorphonuclear leukocyte. The rest of the eye was unchanged.

At the end of twelve hours the changes were similar to those seen at the end of the six hours but were much more intense. The most striking change was in the corneal stroma, where the staining properties were poor and the nuclei were scanty, a condition denoting beginning necrosis of stromal cells. In addition to the edema in the iris and the ciliary body, one observed exudate and areas of hemorrhage.

At the end of twenty-four hours, although all portions of the anterior segment were involved, the changes in the stroma were prominent. No nuclei were seen in the corneal stroma except near the limbus. The outlines of the stromal fibers were indistinct, the staining qualities were poor, and a polymorphonuclear cell infiltrate appeared at the limbus.

At the end of two days the lesions were still advancing. In addition to the necrotic changes previously noted in the stroma, there was now loss of both stroma and epithelium, producing severe ulceration. Polymorphonuclear cell infiltration was beginning to extend into the stroma from the limbus, and in general the stromal fibers were poorly demonstrated. Few stromal nuclei were present, and their staining reaction was poor. There was severe iridocyclitis, and the sclera now showed beginning infiltration.

At the end of three days the pathologic changes were similar to those noted at the end of two days and appeared to have reached their maximum short of corneal perforation.

At the end of five days the changes consisted of corneal ulceration, iridocyclitis and polymorphonuclear cell exudate, filling one-third to one-half the anterior chamber. Early, deep vascularization was seen in the stroma at the periphery of the cornea. Superficial vascularization was uncommon. Mild doses of lewisite may not produce vascularization until the seventh day. Edema of the ciliary processes and disturbance of iris pigment were clearly apparent at this stage. Epithelial regeneration, represented by a single layer of cuboidal cells, had usually begun.





Fig 7—Iris of untreated (above) and treated eyes twelve hours after exposure to lewisite (0.4 mg) Hematoxylin-eosin stain, magnification, 330

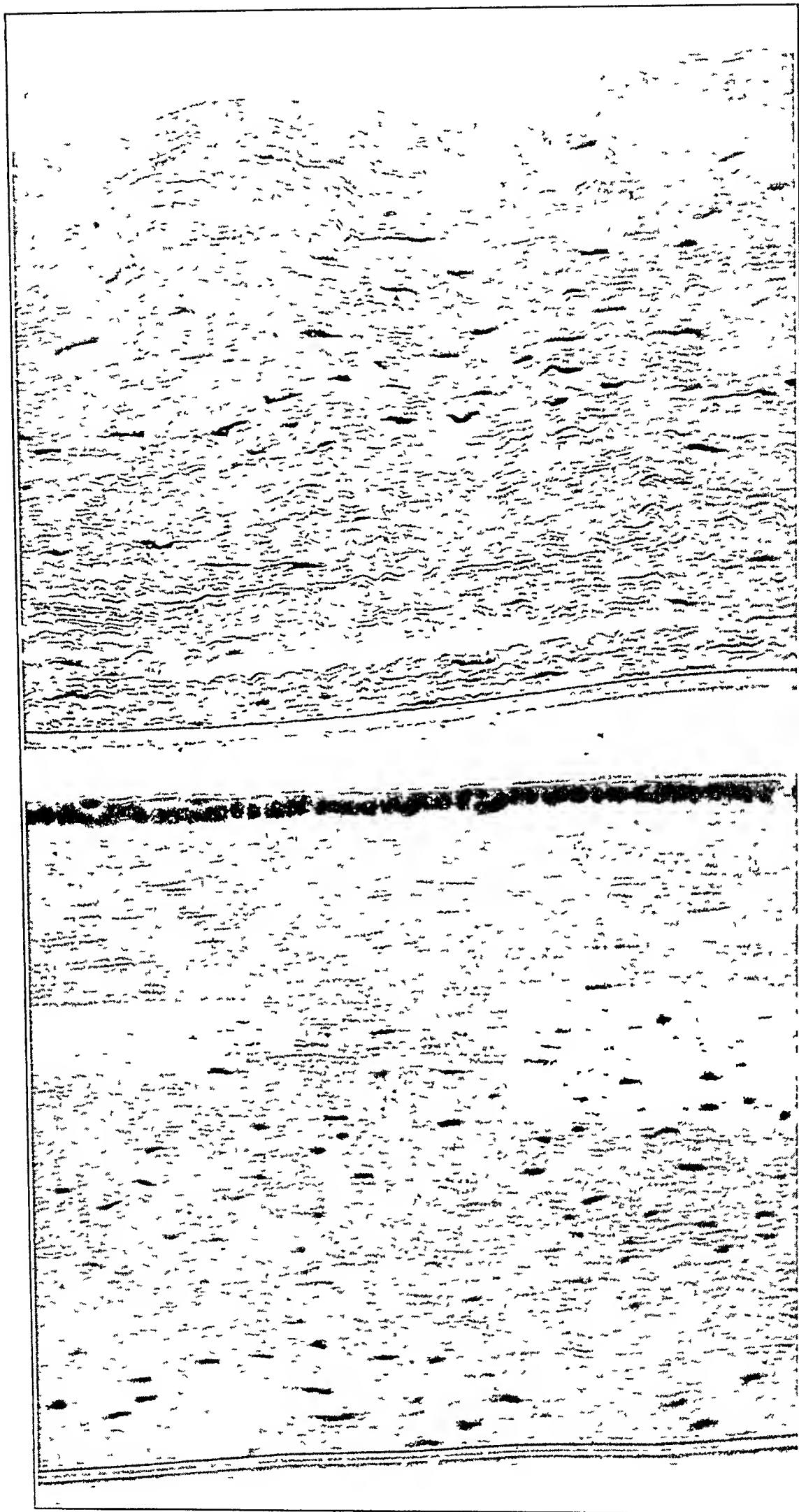


Fig 8—Corneas of untreated (above) and treated eyes twenty-four hours after exposure to lewisite (0.4 mg) Hematoxylin-eosin stain, magnification, 330



Fig 9—Fields from the same corneal sections as those shown in figure 8, but closer to the limbus

By the seventh to the tenth day, in eyes which had not already perforated, some evidence of repair was present. The eye still showed evidence of severe inflammation of the anterior segment. The chief indications of repair were the presence of an irregular epithelium, varying from two to six layers in thickness, and the presence of capillaries throughout the infiltrated areas of the stroma. Regeneration of endothelium was noted by the seventh day. There was no edema of the conjunctiva. In the stroma the polymorphonuclear cell infiltrate was replaced almost entirely by a dense round cell infiltration. Fibro-

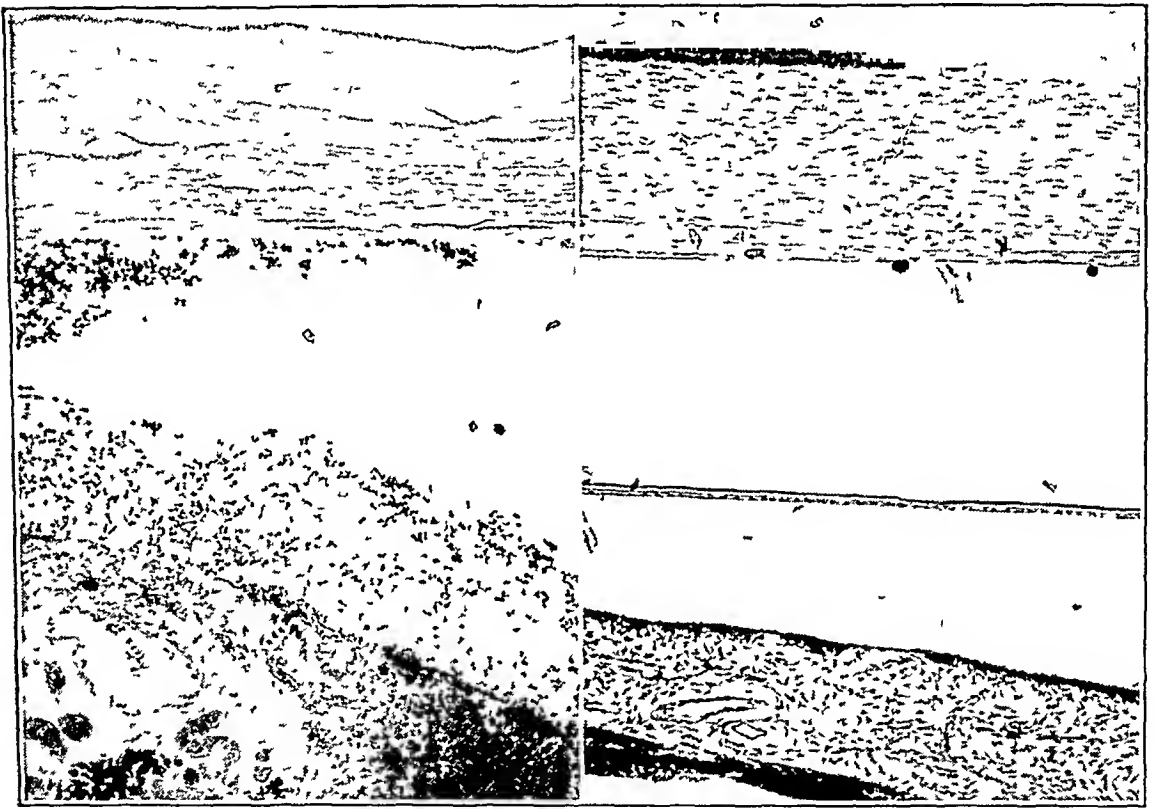


Fig 10—Cornea, iris and anterior chamber of untreated (left) and treated eyes forty-eight hours after exposure to lewisite (0.4 mg). Hematoxylin-eosin stain, magnification, 60.

blasts were present in the deeper layers of the stroma. The exudate in the anterior chamber was beginning to clear, and what remained consisted of round cells. Peripheral anterior synechias were beginning to form. The iridocyclitis was less acute. The iris was usually shortened and thickened.

At the end of fourteen days eyes which previously had had small corneal perforations, now closed, showed evidence of repair similar to that at the end of ten days. The cornea was completely covered by an irregular layer of deeply staining epithelial cells. There was



Fig 11—Corneas of untreated (above) and treated eyes seventy-two hours after exposure to lewisite (0.4 mg) Hematoxylin-eosin stain, magnification of untreated cornea, 170, of treated cornea, 130

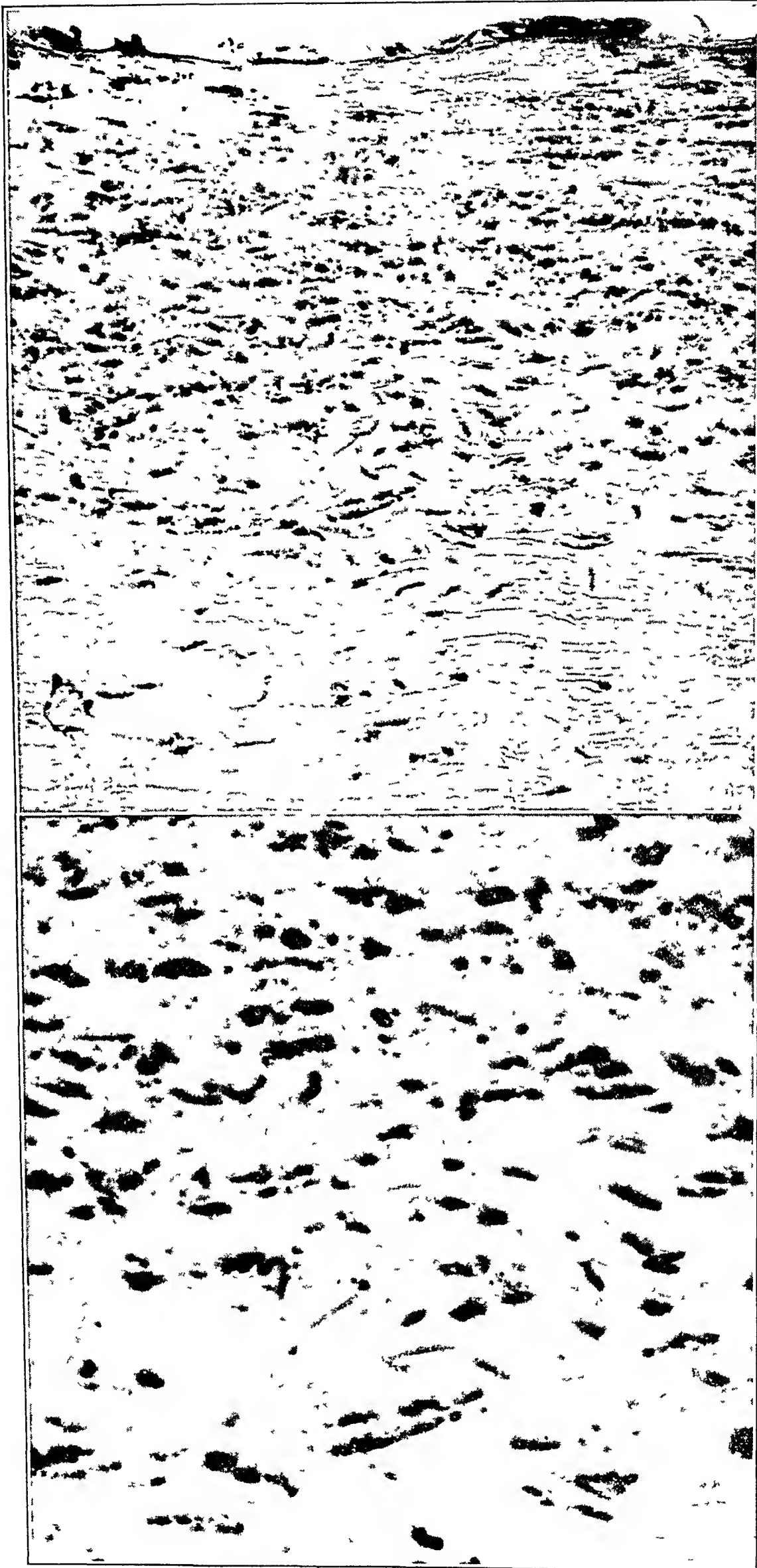


Fig. 12—Tintreated co. ca five days after exposure to lewisite (0.4 mg.)

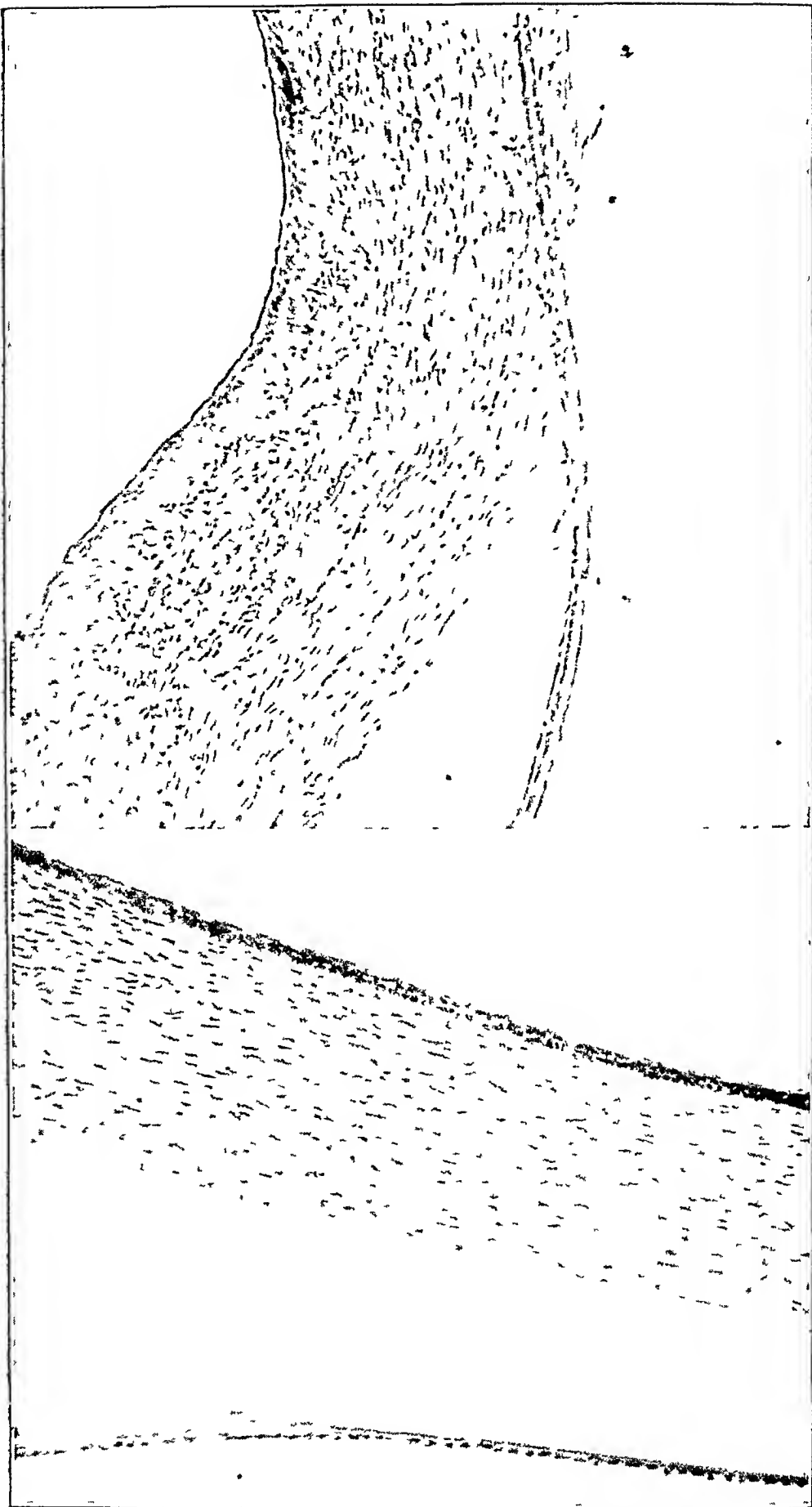


Fig 13—Corneas of untreated (above) and treated eyes ten days after exposure to lewisite (0.4 mg) Hematoxylin-eosin stain, magnification, 170

no conjunctival edema, but the subconjunctival tissue was thickened by fibroblasts. The stroma consisted of irregular bands and islands of round cells. In the middle layers were numerous small and medium-sized vessels. Although the anterior chamber was shallow, there were extensive peripheral synechias. The iris consisted of poorly staining fibroblasts and contained cells in which there was usually much phagocytosed pigment. In the posterior portion of occasional eyes foci of retinochoroiditis were noted.

#### INFLUENCE OF SPECIFIC THERAPY ON OCULAR LESIONS DUE TO LEWISITE

The standard severe ocular lesions produced by lewisite were treated with BAL and studied histologically. These lesions were compared with the untreated lesions described in the preceding<sup>2b</sup> section (figures). These studies showed that the changes in the cornea, the anterior chamber, the ciliary body, the lens and the rest of eye were less severe in the treated than in the untreated eyes. The difference in amount of inflammatory change was evident in twelve hours and continued to be apparent up to fourteen days. At the end of fourteen days, however, there were still changes in the corneal stroma of the treated eye. These changes consisted chiefly in an increase in stromal cells and fibroblasts and in the occasional vascularity of the limbus. The incidence of these scars was proportional to the concentration of vapor or liquid lewisite used to produce the ocular lesion and was inversely proportional to the length of time before application of BAL. In a treated eye there were no changes that could be attributed specifically to the treatment. The changes were similar to those observed in the untreated eye but were of milder degree.

#### SUMMARY

Several features of the pathologic changes in the rabbit eye injured by lewisite ( $\beta$ -chlorovinylchloroarsine) may be emphasized.

- 1 In the early stages changes appeared in the stroma which may be interpreted as a rapidly progressing necrosis of the whole stromal layer. This was seen in the loss of the nuclei of the corneal fibers, the loss of staining ability of these fibers and their loss of outline. These changes were first seen at the end of six hours and reached the maximum in twenty-four hours.

- 2 The infiltration of the stroma began at the periphery at the twenty-four hour stage and was of polymorphonuclear cell type. This infiltrate was replaced by a round cell infiltrate at the end of the ten day stage.



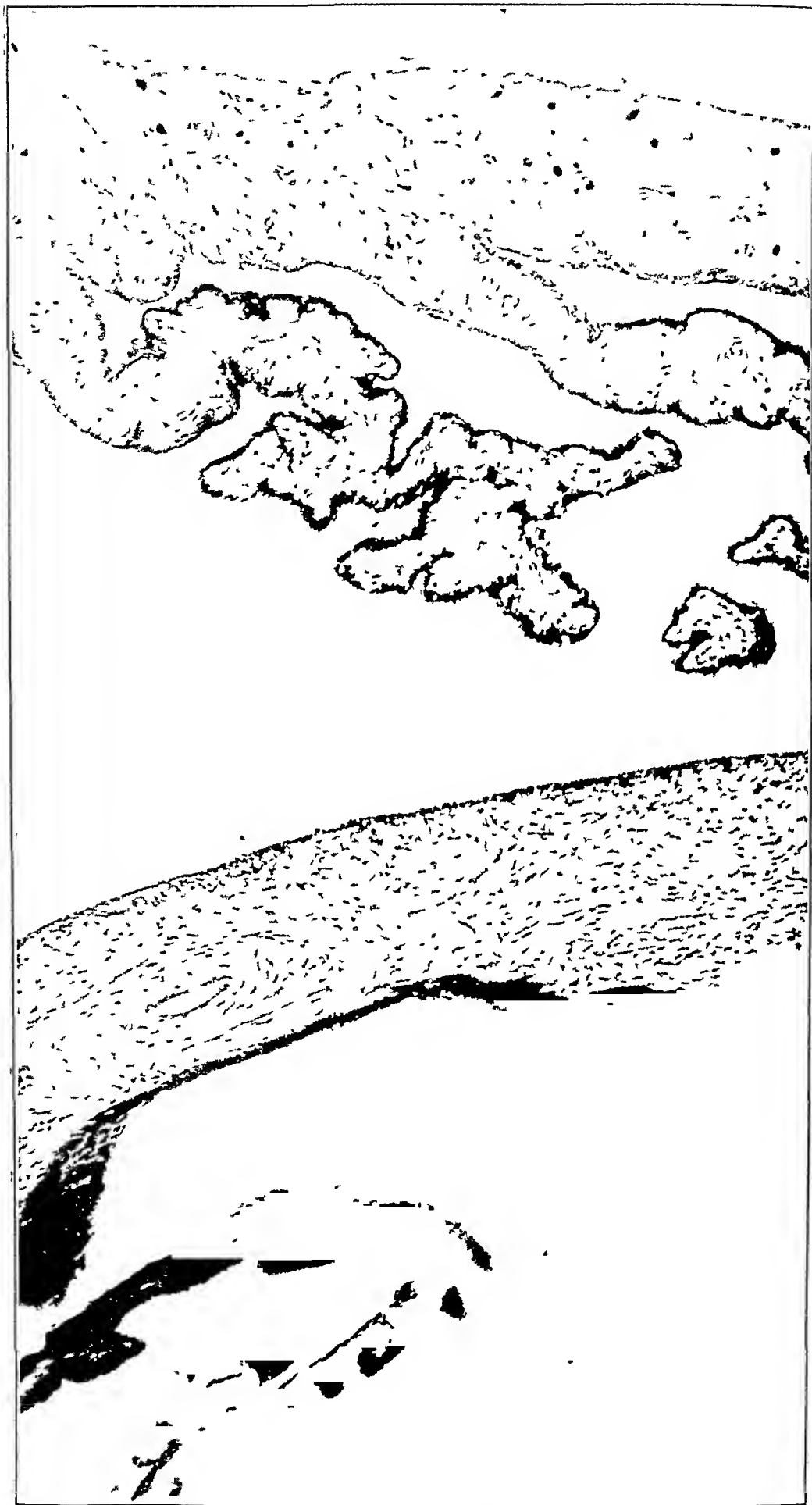


Fig 14—Iris of untreated (above) and treated eyes from the same eyes as those in figure 13, magnification, 170

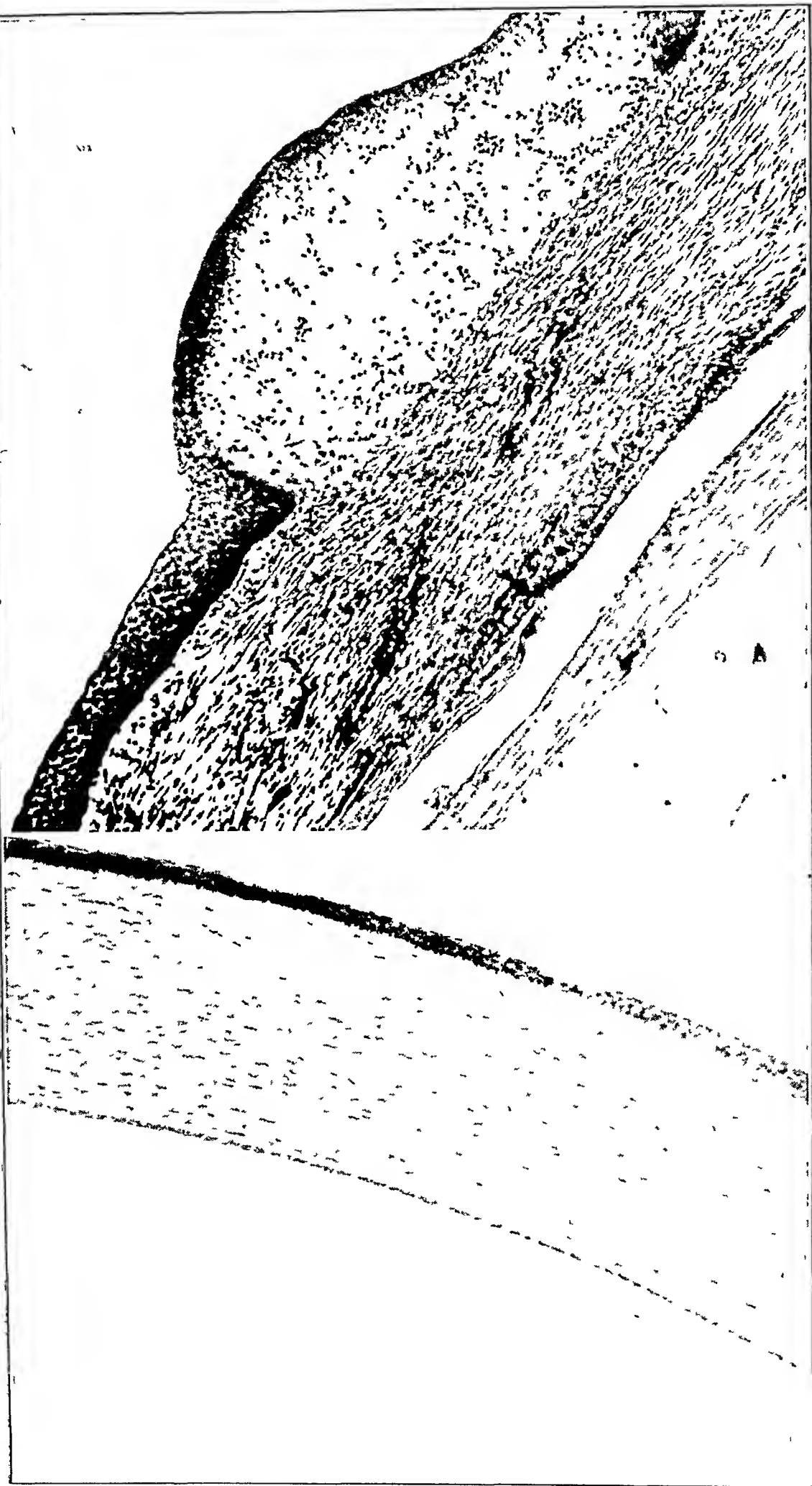


Fig 15—Corneas of untreated (above) and treated eyes fourteen days after exposure to lewisite (0.4 mg) Hematoxylin-eosin stain, magnification of untreated cornea, 170, of treated cornea, 130

3 Vascularization did not make its appearance until the end of five days. This vascularization was in all layers of the stroma but was most prominent in the middle layers. In fourteen days the vascularization was fairly intense.

4 In a treated eye there were no changes that could be attributed specifically to the treatment. The changes were similar to those observed in the untreated eye but were of milder degree.

Hospital of the University of Pennsylvania

## Clinical Notes

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### STUDENTS' MODEL FOR SLIT LAMP BIOMICROSCOPY OF THE AQUEOUS HUMOR

W MORTON GRANT, M D, BOSTON

FOR FAMILIARIZING students with the biomicroscopic appearance of the normal and the abnormal aqueous humor a series of model eyes is of considerable value. The type of model which I have found satisfactory in postgraduate teaching, and which others may similarly find useful, has a convex glass "cornea," a rubber "iris" and a glass "lens," with an "anterior chamber" which can be filled with various artificial "aqueous humors."

The "eye" is constructed from a 5 cc round bottom Pyrex microbeaker, a one hole no. 2 rubber stopper and a piece of 5 mm glass rod. The rubber stopper is freed of talc and shortened to 13 mm by removing a slice from the large end with a knife. The stopper is then pushed small end first as far as it will go into the microbeaker. A space approximating the anterior chamber in shape remains between the round bottom of the beaker and the end of the stopper. Artificial aqueous is introduced into this space through the hole in the stopper by means of a pipet. The hole is then plugged with a 30 mm length of 5 mm glass rod having one end rounded by heating. The round end of the rod is pushed into the hole until it becomes flush with the inner end of the stopper. The completed eye is held by a clamp on a ring stand at a convenient height for inspection with the slit lamp microscope.

The following aqueous preparations have been found satisfactory: (1) distilled water, to simulate normal aqueous, giving an appearance of an "optically empty" anterior chamber, (2) diluted plasma with protein concentrations of 0.2 and 2 per cent to present different intensities of the Tyndall effect, (3) dilute suspension of red blood cells in isotonic solution of sodium chloride, (4) suspension of cholesterol crystals, produced by adding an acetone solution of cholesterol to a relatively large volume of water, and (5) a suspension of diatomaceous earth. The last preparation is convenient for demonstration of the characteristic motion of particulate matter in the anterior chamber, which is caused by thermal convection currents. These currents are usually set up in the model merely by the heating effect of the examining light on the "iris", if this is insufficient, the convection currents may be induced by first warming the model under the hot water faucet.

The model eye described here affords a considerably more realistic optical setting for the inspection of the aqueous humor than do plane-surfaced cells or simple test tubes, which my associates and I had previously employed. Reflections are more like those of the eye, and

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From the Howe Laboratory of Ophthalmology, Harvard Medical School, and the Massachusetts Eye and Ear Infirmary

the presence of an "iris" permits inspection by transillumination. This model is a useful adjunct to enucleated cattle eyes, which are employed in study of the appearance of the cornea.

243 Charles Street

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## EXACT SURFACE LOCALIZATION OF OPHTHALMOSCOPICALLY VISIBLE FOREIGN BODIES IN THE VITREOUS CHAMBER

WALTER S. ATKINSON, M.D., WATERTOWN, N. Y.

**S**MALL foreign bodies in the vitreous chamber which are entangled in the retina and choroid or embedded in the sclera are often not pulled loose with the magnet unless it is applied close to or directly over the foreign body.

The danger is that the foreign body may be incorrectly considered nonmagnetic after a number of unsuccessful attempts to remove it.

The case reported here is one in which this error was made.

J. L. A., a mechanic aged 38, was first seen Oct. 6, 1933. The day before, he had been pounding a piece of metal with a hammer and something flew up and struck him in the left eye. Examination showed vision of 20/15—1 in the right eye and 20/15—3 in the left eye. The conjunctiva was congested, but no wound was seen in the conjunctiva or cornea.

On ophthalmoscopic examination a metallic-looking foreign body was clearly seen embedded in the retina. The location of the foreign body was estimated with the ophthalmoscope to be 15 mm back of the corneal margin and a little below the 180 degree meridian. Further roentgenographic localization was not considered necessary.

A small scleral incision was made 15 mm posterior to the corneal margin and several millimeters below the lateral rectus muscle, as it was not thought necessary to make it directly over the foreign body. Repeated attempts with both the Lancaster hand and the giant magnet failed to withdraw the foreign body.

Ophthalmoscopic examination after the use of the magnets showed the foreign body in the same location and the scleral incision about 7 mm below the foreign body, which was considered close enough to attract a magnetic foreign body 15 by 0.75 by 0.50 mm in size. Consequently, it was thought to be nonmagnetic.

On October 24, eighteen days later, the patient brought to the office the metal he had struck with the hammer at the time of his injury, and it was found to be magnetic.

The foreign body was then watched with the ophthalmoscope by the indirect method while a magnet was applied to the eye. The foreign body could be seen to jump forward a few millimeters each time the current was turned on, showing it to be magnetic. Evidently, application of the magnet to an incision in the sclera 7 mm from the foreign body is not near enough to withdraw it if it is entangled in the tissues. Repeated attempts with both the hand and the giant magnet failed to dislodge the foreign body so that it could be drawn into the anterior chamber.

On October 30, a small pin, similar to a Safar or Walker pin, as used for retinal detachments, was introduced at the estimated site of the foreign body, and ophthalmoscopic examination showed it to be 0.5 mm from and directly above the foreign

body A scleral incision was then made just below the pin and the foreign body removed with the magnet on the first application

The patient was last seen on July 2, 1935, at which time the eyes were quiet and vision was 20/15—1 each eye

Since then the same procedure has been employed for accurate surface localization of ophthalmoscopically visible foreign bodies in the vitreous chamber, with equally satisfactory results

129 Clinton Street

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### MASSIVE MELANOSARCOMA OF THE EYE

LEE W HUGHES, M D, and ANTHONY AMBROSE, M D, NEWARK, N J

THIS case is recorded not so much for its pathologic interest, because the tumor is one of the common ones affecting the eye, but for its photographic value Patients are often seen who have put up with the inconvenience of large tumors in the abdomen and on various parts of the body where they are not exposed One would hardly imagine enduring a tumor such as this one, which was not at all pleasant to look at



Massive melanosaarcoma of the eye

#### REPORT OF A CASE

The patient was a frail white woman aged 74 A reliable history could not be obtained from the patient nor her family The growth had been present in the form seen in the photograph for at least one year "She noticed a growth on the left eye, which gradually enlarged and later started to bleed" At times the bleeding was considerable She kept the tumor covered with tissue paper

On Oct 13, 1945 she was admitted to the Newark Eye and Ear Infirmary. There were pronounced secondary anemia and weakness The mass protruding from the left eye was the size of a goose egg, it was secondarily infected, had a foul odor, bled easily and was a combination of black, blue, green and red colors.

Operation was performed on October 15. Exenteration of the left orbit was done with the Bovie electric knife, the patient being under pentothal anesthesia. There was only moderate bleeding. The brow and the part of the upper lid were left. None of the structures of the orbit could be identified except the sclera, and at one point some dark, blood-stained vitreous was cut through. The orbit was cleaned out completely, the various fissures were palpated, and no extension of the growth could be felt or seen. No vessels had to be tied. The cavity was packed with iodoform gauze. The patient made an uneventful recovery. A photograph taken four months after operation showed almost the entire orbit closed over with skin, with only a very small aperture. There has been no local recurrence or general metastasis to date, the patient has gained weight, and her general health is now good.

It was impossible to get the early history of the ocular trouble, although it was definitely stated that the growth did not originate either in the lids or in the conjunctiva.

The pathologic report was melanosaecoma, made by our own laboratory and by Dr. J. A. Ash, of the Army Institute of Pathology, who expressed the belief that the origin of the tumor was in the eyeball.

965 Broad Street (2)

31 Lincoln Park (2)

# News and Notes

EDITED BY DR W L BENEDICT

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## GENERAL NEWS

**Heed Ophthalmic Foundation**—The Heed Ophthalmic Foundation offers a limited number of fellowships for advanced training in ophthalmology

Only candidates who have completed a minimum of two years' specialized study in ophthalmology are eligible

United States citizenship is required

Application blanks and additional information may be obtained from the secretary of the board of directors, Dr M Hayward Post, 520 Metropolitan Building, 508 North Grand Boulevard, St Louis 3

The first fellowship, to be known as the Gradle Fellowship, has been given to Dr John C Poore, now finishing his residency at the University of California Medical School, and the second, to Dr Herbert B Shields, who is in a like position at Washington University School of Medicine, St Louis

**Twelfth National Assembly of the United States Chapter of the International College of Surgeons**.—The Twelfth National Assembly of this organization will be held from Sept 28 to Oct 4, 1947, at the Palmer House, in Chicago Prof Ignacio Barraquer, of Barcelona, Spain, will speak on his technic for cataract extraction There will be demonstrations and clinics on ophthalmic surgery The chairman is Dr Oscar B Nugent, 231 West Washington Street, Chicago, and the secretary is Dr Otis R Wolfe, Evangelical Deaconess Home and Hospital, Marshalltown, Iowa

**Third Pan-American Congress of Ophthalmology**.—The date of the Third Pan-American Congress of Ophthalmology has been changed to January 4 to 10, 1948 inclusive, owing to the difficulty in arranging hotel accommodations in February

The Congress will be directed by a local committee Dr Tomás R Yanes is the president, Dr Gilberto Cepero, general director, and Dr Miguel A Branly, general secretary

The official program has been definitely closed, and authors should send in their papers, accompanied with a résumé of 400 to 600 words, before Aug 23, 1947, to Dr Tomás R Yanes, Apartado Postal 970, Habana, Cuba, with a copy to Dr Miguel A Branly, Edificio Bacardí, Habana, Cuba, and another copy to the secretary of the association, Dr Conrad Berens, 301 East Fourteenth Street, New York 3, if resident north of Panama, or to Dr Moacyr E Alvaro, 1151 Rua Consolação, São Paulo, Brazil, if resident south of Panama

The Congress will be held in the building of the Medical School of the University of Habana



Dr Thomas D Allen, 122 South Michigan Avenue, Chicago 3, is the director of the courses of instruction Dr Brittain F Payne, 301 East Fourteenth Street, New York 3, is the director of the scientific exhibition

Firms interested in renting space for the commercial exhibit should write to Mr Hector Uribe Trioncoso, 301 East Fourteenth Street, New York 3

Hotel reservations should be made through Dr Miguel A Branly, Edificio Bacardi, Habana, Cuba, and requests should be accompanied by \$10, the amount of the Congress dues. Should a member be unable to attend the meeting, his dues give him the right to receive the *Transactions* of the Congress. Registrations are accepted from this date, and prospective members are advised to make reservations immediately.

Any additional information may be obtained from the general secretary, Dr Miguel A Branly, Edificio Bacardi, Habana, Cuba

#### PERSONAL NEWS

**Bequest to University of Alabama School of Medicine—**Dr Charles A Thigpen, of Montgomery, distinguished Alabama ophthalmologist for the past fifty years, has presented to the University of Alabama School of Medicine the sum of \$10,000, to be used for the conversion of one floor of the Jefferson Hospital into a complete ophthalmic hospital, with operating rooms, laboratory, clinic, residents' quarters and bed space for patients.

This gift is in memory of his late nephew, Dr Job T Cater, who was associated with him in practice. The unit will be known as the Thigpen-Cater Ophthalmic Hospital.

**Appointment of Dr Albert D Ruedemann.**—Dr Albert D Ruedemann, formerly chief of service, the Cleveland Clinics, has been appointed professor of ophthalmology at Wayne University College of Medicine.

# Abstracts from Current Literature

EDITED BY DR WILLIAM ZENTMAYER

## Blind

A STATISTICAL ANALYSIS OF PERSONS CERTIFIED BLIND IN SCOTLAND  
R M DICKSON, Brit J Ophth 30:381 (July) 1946

The analysis comprises the regional clinics for Edinburgh, Dundee, Dumfries, Aberdeen and Inverness for the period from November 1930 to the end of 1938. A total of 5,953 persons were examined by ophthalmologists, and 4,078, or 68.5 per cent, were certified as blind within the meaning of the Blind Persons Act. Visual standards in Scotland fall into three categories: (1) visual acuity of less than 3/60 Snellen, regarded as blindness, (2) visual acuity of 6/60 Snellen or better, not regarded as blindness unless the field of vision is contracted to 10 degrees or less throughout the greater part of its extent, particularly in the lower part of the field, (3) intermediate degrees of visual acuity, i.e., 3/60 Snellen but less than 6/60, regarded as blindness (a) when the visual defect is associated with a restricted field of vision, although it exceeds the limit of 10 degrees laid down in 2 and (b), when the eye is aphakic. The chief causes of blindness were cataract, 17.1 per cent, myopia, 14.9 per cent, chronic septicemia, 10.8 per cent, syphilis, 10 per cent, glaucoma, 8.1 per cent, and injury, 5.9 per cent. A new significance is given to causes operating in the early years of life, the most important causes from this point of view are chronic septicemia, congenital anomalies, ophthalmia neonatorum and congenital syphilis, which together account for 44.5 per cent of the total duration "patient years" of blindness. Cataract, the cause of the greatest number of cases, is relegated to seventh place, with an average of five years of blindness. Miners, metal workers and spinners and weavers have a higher than average incidence of blindness. When cases of traumatic blindness are omitted, the total incidence of blindness is about the same in the two sexes.

W ZENTMAYER

## Congenital Anomalies

A CASE OF SECONDARY OBLIQUE FACIAL CLEFT A MELLICK, Brit J Ophth 30:221 (April) 1946

A man aged 20 presented in the left eye a narrow bridge of skin passing down from the upper lid in the region of the lacrimal punctum to become continuous with the semilunar fold. In the center of the bridge of skin, in the line of the upper lid margin, there was a small depression, which admitted a fine horsehair in a medial direction for a distance of about 1.5 mm. The lower lid showed a slight degree of notching between the inferior punctum and the inner canthus. There were no other abnormalities of the eye. The right eye was normal. It is assumed that adhesion or pressure of amniotic bands is the cause of this anomaly.

The article is illustrated

W ZENTMAYER

## Cornea and Sclera

INDICATIONS AND CONTRAINDICATIONS FOR KERATOPLASTY AND KERATECTOMIES R CASTROVIEJO, *Am J Ophth* 29:1081 (Sept) 1946

Castroviejo concludes that keratoplasty and keratectomy are no longer procedures of uncertain results and that further study may permit opening a larger field for this type of surgery W S REESE

CORNEAL ULCER TREATED WITH STREPTOMYCIN N F ALBERSTADT and A H PRICE, *Am J Ophth* 29:1106 (Sept) 1946

Alberstadt and Price found streptomycin, a nontoxic antibiotic derived from *Actinomyces griseus*, to be a useful adjuvant in the treatment of corneal ulcer W S REESE

KERATOCONJUNCTIVITIS SICCA J M RICHARDS and H H ROMAINE, *Am J Ophth* 29:1121 (Sept) 1946

Richards and Romaine present a case of the purulent conjunctival form of erythema exudativum multiforme (Stevens-Johnson disease) and note the association of keratoconjunctivitis sicca with this disease. Emphasis is placed on the dire ocular sequelae W S REESE

EDEMA OF CORNEAL EPITHELIUM CAUSED BY ATABRINE [QUINACRINE] F M REESE, *Bull Johns Hopkins Hosp* 78:325 (June) 1946

Reese presents records of 3 patients who complained of severe blurring of vision while taking 0.2 Gm of quinacrine hydrochloride a day. One patient had received a larger therapeutic course of quinacrine twenty-one days previously, the second had received therapeutic courses of the drug repeatedly for almost two years up to two months previously, and the third patient had received 0.2 Gm of quinacrine hydrochloride a day for twenty-seven days up to nine days before admission. Examination of the eyes of these patients showed edema of the corneal epithelium, "bedewing" of an unusually fine texture and uniform appearance with the slit lamp. All 3 soldiers appeared to be in excellent health. In 2 cases minimal corneal changes, visible only on examination with the slit lamp, persisted for three weeks when 0.1 Gm of quinacrine hydrochloride a day was taken. These changes finally disappeared three weeks after the drug had been discontinued and 0.6 Gm of quinine a day substituted. A small therapeutic course of quinacrine given to each patient after all signs of epithelial edema with the slit lamp had disappeared resulted in a full blown recurrence in all 3. In each patient the visual disturbance was most severe when he was receiving more than the usual suppressive dose of quinacrine hydrochloride (0.1 Gm per day). Reduction of the dose to the usual suppressive level did not suffice to clear up the condition entirely. This process is apparently reversible and does not result in permanent damage to the ocular tissues J A M A (W ZENTMAYER)

SURVEY OF THE TREATMENT OF TRAUMATIC CORNEAL ULCER A  
SMITH, Brit J Ophth 30:178 (March) 1946

A study was made of 351 patients with corneal ulcers admitted to the Royal Hospital, Sheffield, for inpatient treatment. Of these, 89 had ulcers of spontaneous origin (at least they gave no history of trauma) and 262 had traumatic ulcers. The visual acuity four months or longer after discharge showed that 14.3 per cent had no useful vision (6/60 or less), 78.5 per cent had vision of 6/12 or better and 48.2 per cent had vision of 6/6 or better.

Significant aspects of treatment were (1) the notable drop in number of days in the hospital after the internal administration of sulfonamide drugs became a routine treatment and (2) the effectiveness of pyrexial therapy (Coley's fluid [a mixed bacterial vaccine from *Streptococcus pyogenes*, *Streptococcus erysipelas* and *Bacillus prodigiosus*]) combined with simultaneous administration of sulfonamide compounds. The latter may largely account for the excellent visual results obtained, particularly in the cases of hypopyon.

W ZENTMAYER

CORNEAL VASCULARIZATION IN CHRONIC DISEASE P A GARDINER,  
Brit J Ophth 30:581 (Oct) 1946

The aim of this study is to analyze the manifestations of corneal vascularization in series of chronically ill persons and to discuss their significance. In no case was there a double pathologic process, and in every case the disease was sufficiently severe to warrant either admission to a hospital or invaliding from the service. One hundred and ninety-one service patients were examined with the slit lamp. From this survey the following conclusions were drawn. The frequency and degree of corneal vascularization increase with the severity of the disease. Corneal vascularization is more pronounced with rheumatoid arthritis and fibrosis and with duodenal ulceration than with the other gastrointestinal diseases, osteoarthritis and a miscellaneous group of diseases. There is more corneal vascularization among ill patients who complain of ocular symptoms than among those with no ocular symptoms. Lacrimation, grittiness in the eyes and conjunctival congestion accompany corneal vascularization more often than do other symptoms, though vascularization does occur without any symptoms. In surveys for comparative health, only healthy subjects should be examined if conclusions are to be drawn about their nutrition. The presence of corneal vascularization may prove to be of considerable value in the differential diagnosis of diseases with functional imitations.

W ZENTMAYER

SATTLER'S VEIL J DALLOS, Brit J Ophth 30:607 (Oct) 1946

After discussing the requisites for properly fitting contact lenses, Dallos takes up the problem of the blur which develops only after several hours of wear. Patients who wear contact lenses for two hours or more (sometimes less) will, as a rule, experience a corneal haze similar to that accompanying a mild attack of glaucoma. The biomicroscope shows a faint epithelial edema attended with a slight bluish haze in daylight and colored haloes around lights in the dark. After removal of the lens, the condition clears in twenty to thirty minutes. To this

condition the term Sattler's veil is given. The veil is even and is macroscopically diffuse. As a rule it starts as a blur over the entire cornea, but in some cases it may begin in an odd sector somewhere in the periphery. In morbid cases vesicles may form. Secondary infection with permanent damage has occurred in cases in which the veil has been ignored. The cause of the veil is fully discussed. The fact that a loosely worn, comfortable contact lens allows a longer span of clarity, that with insensitive or hypesthetic corneas there is hardly any veiling and that increasing use makes for decreasing veiling, all point to the tension of the eyelids as playing an important role in pressing the lens so tightly onto the surface of the eye as to interfere seriously with some of its physiologic functions. The author has experimented with carefully adjusted lenses so as to keep up air circulation through one or more active perforations and yet remain in constant contact over the pupillary area. There has invariably been an absence of veiling in all cases in which the lenses are fitted on these lines.

W ZENTMAYER

### Experimental Pathology

#### THE ROLE OF LENS SUBSTANCE IN EXPERIMENTAL GONORRHEAL IRITIS

M J DRELL, M BOHNHOFF and C P MILLER, *Am J Ophth* 29: 1263 (Oct) 1946

Drell, Bohnhoff and Miller report experiments on rabbits in which inoculation of gonococci into the anterior chamber with injury to the lens caused a moderately severe and chronic inflammation, but produced mild inflammation when there was no injury to the lens. Inoculation of a mixture of gonococci and lens substance usually caused a similar mild reaction. Lens substance in vitro, particularly after autolysis, prolonged the survival time of the gonococci.

W S REESE

### General

#### OCCUPATIONAL EYE DISEASES JOSEPH MINTON, *Brit M J* 1:211 (Feb 9) 1946

In the diagnosis and treatment of injuries and diseases of the eye the author emphasizes the importance of investigating the nature of the patient's occupation. Many cases of acute and chronic conjunctivitis or keratitis owe their origin to occupational factors, just as obscure cases of retinitis, retrobulbar neuritis, ocular palsies and amblyopia should make one think of chronic poisoning arising from industrial solvents.

Among the causes of acute and chronic keratitis there is mentioned the injury from hydrogen sulfide, which is used in the artificial silk industry and in the sugar industry. Workers in furniture trades, metal industries and straw hat factories occasionally acquire keratitis from the use of benzene and similar solvents of varnishes and shellac. Agricultural workers suffer from exposure to various weeds and peat dust. Lenticular opacities were observed in 20 per cent of persons employed in a glass industry. These opacities were found to be due to infra-red rays and were situated in the posterior cortex of the lens. Similar changes were observed in furnace workers. The development is slow, and it frequently takes from ten to twenty years of work for these

opacities to develop The most important of the industrial poisons are lead, derivatives of benzene, carbon bisulfide, methyl alcohol, arsenic and its derivatives, carbon tetrachloride and trichloroethylene These substances cause toxic amblyopias, optic neuritis and ocular palsies

In order to deal with these problems of occupational diseases and ocular injuries, the Royal Eye Hospital has established a department of industrial ophthalmology The ophthalmologist in attendance has the advantage of the assistance of skilled engineers, safety officers and makers of preventive appliances to advise him on technical problems

The largest number of cases referred to the department are those of corneal foreign bodies from grindstones Ocular disturbances due to welding are described The symptoms consist in photophobia and lacrimation, conjunctivitis and mild superficial keratitis were found to be present The author recommends treatment with epinephrine hydrochloride (1 2,000), in drops, and phenacaine or tetracaine hydrochloride, 1 per cent, cold applications are advisable A certain number of welders exhibited chronic superficial keratitis, with multiple erosions on the cornea, and complained of blurring of vision, a sense of grittiness and photophobia Chronic conjunctivitis is often due to the patient's working in dusty workshops with insufficient ventilation

The author concludes with the statement that the search for occupational causes in cases of ocular inflammation or injury is all-important It is not sufficient to search for a septic focus, but the working conditions should be inquired into In a department of industrial ophthalmology not only can the eye be properly treated, but the cause and prevention should be investigated

ARNOLD KNAPP

### General Diseases

PERIARTERITIS NODOSA WITH INVOLVEMENT OF THE CHOROIDAL AND RETINAL ARTERIES J GOLDSMITH, *Am J Ophth* 29:435 (April) 1946

Goldsmith reports a case of periarteritis nodosa with necropsy observations and claims that the diagnosis was first made during life by ophthalmoscopic observation in conjunction with the physical findings and the clinical course The possibility of inducing hyperergic states within the human body by administration of sulfonamide drugs and serum is discussed

W S REESE

EARLY OCULAR MANIFESTATIONS IN THE LAURENCE-MOON-BIEDL SYNDROME D J LYLE, *Am J Ophth* 29:939 (Aug) 1946

Lyle reports 2 cases and describes the Laurence-Moon-Biedl syndrome He notes that resemblance to hereditary optic atrophy (Leber's disease) and the various types of cerebromacular degeneration with central scotoma, loss of vision and cerebral symptoms is remarkable in the early stages of the two conditions In the later stages the pigmentary degeneration may be confused with typical retinitis (retinosis) pigmentosa by the casual observer who fails to take a detailed history of the case and to make a complete examination in order to reveal the other components of the syndrome

W S REESE

INTRAOCULAR MANIFESTATIONS OF ACUTE DISSEMINATED LUPUS  
ERYTHEMATOSUS F L P KOCH and W P MCGUIRE, Am J  
Ophth 29 1243 (Oct ) 1946

Koch and McGuire report a rather baffling case of a disorder diagnosed as acute disseminated lupus erythematosus in which marked retinal vascular disease was present and progressed up to the time of death

W S REESE

NUTRITIONAL AMBLYOPIA IN AMERICAN PRISONERS OF WAR LIBERATED  
FROM THE JAPANESE S M BLOOM, E H MERZ and W W TAY-  
LOR, Am J Ophth 29:1248 (Oct ) 1946

Bloom, Merz and Taylor report early ophthalmic changes in American soldiers while in Japanese prison camps and residual changes in some of these men after liberation. They showed central or cecocentral scotoma with defective vision and pallor of the nerve heads, apparently due to lack of thiamine. If treatment is not instituted early enough, the condition becomes irreversible, as evidenced by lack of response to intensive vitamin therapy

W S REESE

IMPORTANCE OF THE HISTORY IN THE DIAGNOSIS OF OCULAR TUBER-  
CULOSIS JEAN FERRIE, Ophthalmologica 111:332 (June) 1946

Since it is usually impossible to perform a biopsy and the laboratory tests are generally unreliable, a diagnosis of ocular tuberculosis must be based primarily on the patient's history, the results of general examination and the reactions to the tuberculin and therapeutic tests. This article lays stress on the history of previous tuberculosis in both the patient and his family

F H ADLER

### - Glaucoma

GLAUCOMA PHACOGENETICUM, WITH ANATOMIC OBSERVATIONS  
REPORT OF TWO CASES W P C ZEEMAN, Ophthalmologica 106:  
136 (Sept ) 1943

Two cases are reported of hypermature cataract with subsequent acute inflammation and glaucoma. The eyes were removed and examined histologically. Numerous enlarged cells with orange-colored contents were observed in the angle of the anterior chamber after appropriate sudan staining. Similar cells were seen in the spaces of Fontana and in the stroma of the iris. The optic disk showed edema and a deposit of amorphous substances without any typical inflammatory infiltrates. The author believes that the inflammatory changes were due to a release of toxins from the disintegrating lens substance

F H ADLER

### Injuries

MUSTARD-GAS BURNS OF HUMAN EYES IN WORLD WAR II G I UHDE,  
Am J Ophth 29:929 (Aug ) 1946

Uhde reports on 790 cases of mustard vapor (dichloroethyl sulfide) burns acquired accidentally at the Edgewood Arsenal. He presents a classification, with illustrative cases, and discusses the clinicopathologic observations

W S REESE

A STUDY OF LEWISITE LESIONS OF THE EYES OF RABBITS I MANN,  
A PIRIE and B D PULLINGER, *Am J Ophth* 29:1215 (Oct)  
1946

Mann, Pirie and Pullinger, in experiments on rabbits, found no condition similar to delayed mustard gas (dichloroethylsulfide) keratitis resulting from lewisite (betachlorovinylchloroarsine). The eyes recovered, showed stable scars or were destroyed. The main points of interest were (1) peculiar effect on the corneal endothelium and corneal corpuscles, (2) miosis, (3) intense, but transient, edema of the lids and conjunctiva, (4) intense edema of the cornea, reaching a maximum after the swelling of the lids had subsided, (5) characteristic type of vascularization, (6) involvement of the iris and ciliary body, with mesodermal depigmentation and shrinking and with the displacement of ectodermal pigment, and (7) an apparently specific effect for the total dose entering the eye rather than for the anatomic site of the lesion.

W S REESE

THE USE OF CONTACT CORNEAL RINGS IN X-RAY LOCALIZATION OF  
INTRAOCULAR FOREIGN BODIES J L REIS, *Brit J Ophth* 30:462  
(Aug) 1946

To Reis, the Sweet, the McGrigor or the Kraus and Briggs method of roentgenologic localization of intraocular foreign bodies seems to be the best, but each of these technics requires special apparatus. To avoid some of the objections to previously described contact methods, Reis employs thin metal rings exactly fitting the corneal margin. The rings are made of lead and tin alloy, about 0.1 mm thick. Such rings give sufficiently distinct shadows on roentgenograms to enable one in the commonly known way (by making a diagram) to localize a foreign body from the relations shown by the posteroanterior and lateral roentgenographic exposures. The method of construction and application and their advantages are described in detail. The article is illustrated.

W ZENTMAYER

### Instruments

USE OF THE SCHIØTZ TONOMETER H ARRUGA, *Arch Soc de oftal hispano-am* 6:85 (Jan) 1946

Arruga reports an ingenious method to facilitate the reading of the tonometer of Schiøtz without having to refer to the scale on the card. It consists in fixing in the two small pivots that limit the excursions of the needle and which hold the white celluloid plaque in which the graduations of the instrument are marked a piece of cardboard in which he has marked the amount of pressure in millimeters of mercury that corresponds to each of the lines in the celluloid plaque of the tonometer. A constant weight of 7.5 Gm has to be used. As different tonometers have different scales, different cards have to be used for them. Illustrations of his device are shown.

H F CARRASQUILLO



## Lens

SPONTANEOUS RUPTURE OF THE LENS CAPSULE IN ANTERIOR LENTICONUS L H EHRLICH, *Am J Ophth* 29 1274 (Oct ) 1946

Ehrlich reports the case of a 12 year old boy who first noted defective vision in the right eye three years before, following a mild blow in a fist fight Vision in this eye was 4/200, and examination with the slit lamp revealed a bulging forward of the anterior capsule in the axial region This elevation seemed filled with a clear fluid A month later a tear was discovered at the summit of the bulge, and soft lens material protruded into the anterior chamber During this time changes in the lens of the left eye made their appearance and at the end of a year assumed the form of a horseshoe

W S REESE

CONTUSION CATARACT OF THE ANTERIOR LENS CAPSULE H F SUDRANSKI, *Am J Ophth* 29:1281 (Oct ) 1946

Sudranski reports the case of a youth aged 20 who was struck in the right eye by a blast of compressed air Roentgenologic examination revealed the presence of two metallic foreign bodies, and a healed perforating wound of the cornea and a hole in the iris were noted Focal and biomicroscopic examinations showed a complete reproduction of the circular muscle fibers of the pupillary sphincter and of the radial pattern of the iris on the anterior capsule of the lens

W S REESE

A NEW METHOD OF KERATOTOMY FOR USE IN THE CATARACT OPERATION A BUJADOUX, *Arch d'opht* 6 22, 1946

The author emphasizes the necessity of an exactly placed and directed incision for the cataract operation In this paper he presents a knife which makes the incision with a direct thrust across the anterior chamber He insists that absolute immobilization of the eye is necessary and describes his method of accomplishing this

S B MARLOW

LIGHT REFLEXES ASSOCIATED WITH SPHEROPHAKIA A E SCHMID, *Ophthalmologica* 111: 359 (June) 1946

A case is reported of so-called dysmorphodystiopia mesodermalis congenita, a type described by Marchesani, in which there were a luxated spherophakic lens in the anterior chamber of one eye and a sub-luxated lens in the opposite eye It is well known that the normal lens when dislocated into the anterior chamber shows under certain conditions of illumination an illuminated line around the entire equator, which is known as the gold edge, or "*gold Rand*" In the case of the spherophakic lens other reflex streaks besides this equatorial one appear An illustration is given of these reflex streaks, and the author discusses the origin and nature of the light reflexes in spherophakia and microphakia

F H ADLER

CONTUSION AND MASSAGE CATARACTS A E SCHMID, *Ophthalmologica*  
111:365 (June) 1946

Under ordinary conditions, the movements of the iris on the surface of the lens, caused by changes in the size of the pupil, do not produce any loss of transparency of the lens. Movements of the lens itself against the iris, however, such as occur with a luxated lens in the anterior chamber, can cause such opacities. The author observed such opacities in a case of spherophakia described in a previous article. The origin of these opacities is discussed.

F H ADLER

### Neurology

BOWEN'S DISEASE OF THE CONJUNCTIVA V R KHANOLKAR, *Am J Ophth* 29:515 (May) 1946

Khanolkar observed a case of Bowen's disease of the conjunctiva for a period of eight and a half years and studied tissue removed on four different occasions, during this period the tumor changed from a relatively benign to a definitely malignant one. The treatment of choice is unfiltered radiation from a bare radium bulb.

W S REESE

HYSTERICAL AMBLYOPIA E R YASUNA, *Am J Ophth* 29:570 (May) 1946

Yasuna observed 15 cases of hysterical amblyopia at the Fort Snelling separation center. He found the distance discrepancy in the peripheral fields the most important aid in diagnosis. He states that disability ratings should be based on the severity of the hysteria and not on the amount of visual or field loss.

W S REESE

THE EYE EXAMINATION IN THE DIFFERENTIAL DIAGNOSIS OF THE DISORIENTED PATIENT B MILDER, *Am J Ophth* 29:953 (Aug) 1946

Milder found ophthalmic examinations of the greatest significance in the early diagnosis of psychotic and comatose states resulting from brain tumor and cerebrovascular disease, especially hypertensive encephalopathy and cerebrovascular accidents. Of less value were the ocular findings in diagnosis of uremic coma and syphilis of the central nervous system.

W S REESE

### Ocular Muscles

A CONTINUATION OF THE SCREEN TEST H G MARTIN, *Am J Ophth* 29:196 (Feb) 1946

Martin offers a method as a continuation of the usually performed screen test which aids in defining the offending mechanism in conditions of variation from accepted normal balance. Used with other muscle tests for near vision, these tests afford information regarding the values of the most important contributors in the combined function of vergence. The objective nature of these tests permits their use on uncooperative and very young patients.

W S REESE

THE SURGICAL TREATMENT OF STRABISMUS D B KIRBY, Am J  
Ophth 29: 408 (April) 1946

Kirby feels that operation may well be performed at an early age if strabismus is not corrected by orthoptic measures and that operation may be planned beforehand, but the actual details and extent of the procedure may not be evident until the muscles are exposed. It is better to do too little than too much and if further surgical intervention is necessary to wait until the tissues have healed and resolved. He urges proper care and orthoptic training after operation.

W S REESE

### Operations

METHACRYLIC RESIN IMPLANT FOR SUNKEN UPPER LID FOLLOWING  
ENUCLEATION H S SUGAR and H J FORESTNER, Am J Ophth  
29: 993 (Aug) 1946

Sugar and Forestner describe a method of implanting a methylmethacrylate implant into the upper lid to obviate the sinking sometimes seen after enucleation.

W S REESE

### Orbit, Eyeball and Accessory Sinuses

DECOMPRESSION OF ORBIT J S GUYTON, Surgery 19: 790 (June)  
1946

Guyton advises decompression of the orbit for the reduction of severe exophthalmos, in which there is an increase in the weight of all orbital structures (muscles, fat, lacrimal glands) due to increased water storage, with progressive hypertrophy and degeneration of the extraocular muscles, scattered lymphocytic infiltration and progressive fibrosis of the orbital structures. Incomplete closure of the lids and impaired nutrition may cause corneal ulceration. The increase in retrobulbar pressure may be great enough to cause papilledema and secondary atrophy of the optic nerve. Loss of vision has been reported in scores of cases. The orbit can be decompressed into the anterior cranial fossa, the frontal and ethmoid sinuses or the temporal fossa. The author describes an improved technic utilizing the temporal fossa. This operation is the least dangerous of the various decompressions, being extracranial, performed in an aseptic field and not endangering any important structures. It leaves no visible scar or other cosmetic defect and gives a completely adequate decompression. Its use is recommended for patients desiring cosmetic improvement of exophthalmic disfigurement as well as for those with threatened impairment of visual function.

J A M A (W ZENTMAYER)

REPORT ON A CASE OF HYDROPTHALMIA (BUPHTHALMOS)  
E EPSTEIN, Brit J Ophth 30: 476 (Aug) 1946

The case described had many features which might have suggested the diagnosis of megalocornea but proved to be one of hydrophthalmos. It indicates that the diagnosis of megalocornea in the absence of a familial history can be most difficult and should then be made reservedly.

W ZENTMAYER

### Parasites

NOTES ON ONCHOCERCIASIS IN GUATEMALA R PACHECO-LUNA, Brit J Ophth 30:234 (April) 1946

Onchocerciasis (filariasis) or onchocercosis, also known as Roble's disease, or blinding disease of Guatemala, is a new nosologic entity, caused by a parasite which profoundly affects the visual organ in a great number of cases. It is estimated that 20,000 persons in Guatemala are infected with onchocerciasis. Ocular manifestations are observed in 30 per cent of these patients, and 2 per cent are blind. At first the biomicroscope shows tenuous superficial punctate keratitis, consisting of avascular punctiform infiltrations. Iritis may be present independently or may accompany the keratitis. The process usually extends to the uveal tract, and degenerated pigmentary lesions of the choroid and retina with no relation to the vessels develop, and the process may end in phthisis of the eye. No therapeutic agent has been found which acts with good results on the parasites.

W ZENTMAYER

### Pharmacology

CONCENTRATION OF PENICILLIN IN THE AQUEOUS HUMOR FOLLOWING SYSTEMIC ADMINISTRATION A E TOWN and M E HUNT, Am J Ophth 29:171 (Feb) 1946

Town and Hunt found penicillin present in the aqueous at a lower level than that of the blood after systemic administration. After paracentesis, however, the aqueous is reformed in forty minutes, with a concentration approximating that of the blood serum.

W S REESE

### Refraction and Accommodation

CORRESPONDING AND OBLIQUE MOVEMENTS IN RETINOSCOPY J I PASCAL, Eye, Ear, Nose & Throat Monthly 25:148 (March) 1946

Corresponding movements are movements in the same plane as the mirror movements. Oblique movements run along a meridian different from that of the mirror movements. The presence of astigmatism is noted at once when on the initial mirror movements the reflex movements are "oblique." The principal purpose of noticing the oblique movements is for the determination of the correct axis of astigmatism when present. Observations of oblique movements are important in cylinder retinoscopy.

A COWAN

### Retina and Optic Nerve

EFFECT OF ANTEPARTUM VITAMIN K ON RETINAL HEMORRHAGE H F FALLS and H N JUROW, J A M A 131:203 (May 18) 1946

The observations were made on 432 patients. Of the 151 patients who received antepartum treatment with vitamin K, 47, or 31.1 per cent of the newborn had retinal hemorrhages, and of the 281 who did not receive vitamin K ante partum, 94, or 32.4 per cent, had retinal

hemorrhages A difference of 13 per cent in the incidence of retinal hemorrhages in the two groups can hardly be called significant as to the effectiveness of vitamin K The following conclusions are reached

Vitamin K administered either ante partum or intra partum does not reduce the incidence of retinal hemorrhages in the newborn

Vitamin K thus administered raises the infant prothrombin time during the physiologic decline

J A M A (W ZENTMAYER)

#### THE DIAGNOSTIC AND CLINICAL VALUE OF SOME FORMS OF RETINAL ANGIOSPASM N PINES, Brit J Ophth 30:470 (Aug) 1946

Pines tries to establish a connection between the ophthalmoscopic picture of the retina and the result of the general clinical examination, especially that of the arterial circulation After describing the normal narrowing of the arteries from the surface of the disk to the periphery, the author states that in many healthy young men, usually those below 30 years of age, in spite of absence of translucency of the retinal vessels, this gradual diminution of the arterial lumen is present, but in persons of early middle age it is quite the reverse If the artery is followed from a point near the disk, a tiny bit of it becomes slightly narrower, say to one-tenth its volume, and immediately after that it becomes wider again and then gradually narrows until it disappears altogether It may affect tiny bits, up to 1/20 disk diameter, in the primary and secondary branches This physiologic angiospasm of retinal arteries is part of a general one, i e, the retina is subject to the influence of the general vasomotor center The symptom by itself is only the first step in the accommodation of the body to a new condition of vascular life The clue to the diagnosis are the sphygmomanometric, dynamometric (for the retina) and oscillometric readings, together with the general clinical picture

W ZENTMAYER

#### Trachoma

#### NECESSITY OF AN INTERNATIONAL STUDY CENTRE OF TRACHOMA L POLEFF, Brit J Ophth 30:287 (May) 1946

Poleff makes a plea for an international trachomatologic institute He is of the opinion that Morocco would be the most convenient place for its establishment, a trachoma country *par excellence*, situated between the ancient and the new continents

W ZENTMAYER

## Book Reviews

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**Tabulae pseudo-isochromaticae B.-K.: Plates for testing colour vision.**

By C G Bostrom and I Kugelberg Price, 35 7 crowns Pp 3  
Stockholm, Sweden Kifa, 1943

This is a new series of pseudoisochromatic plates for testing red-green vision published in 1943 and only recently reaching this country. It was designed by C G Bostrom, ophthalmic adviser to the Board of Swedish Railways, and I Kugelberg, docent in ophthalmology at the Karolinska Institute, Stockholm, Sweden. The Swedish medical board has officially prescribed the use of this test for examinations of the color sense for traffic and transport service. (In preparing this review, I have taken the liberty of including information received in a personal communication from the publisher of the test.)

The series consists of 20 plates of uniform size, mounted so that their serial order permits variation. There are 15 plates with one numeral, 2 plates with a serpentine line and three dissimulation plates without design. All plates have the same outline pattern, which is filled with the same mosaic of round dots, 2.5 mm in diameter, arranged in staggered horizontal rows. In the significant plates some of the dots are colored in one hue to form a design on the background dots, which are colored in a different hue. In all, fifteen paired colors are thus presented, planned, as stated by the publisher, to cover the confusion color pairs of practically all forms of defective red-green vision. Three value levels are presented in the dots of both figure and ground, and all colors are of low chroma. Information is not given as to the basis on which the confusion pairs were selected, and no differential classification of the extent or the type of defect revealed by the various plates is claimed. The test is intended for screening purposes only.

A three page leaflet of directions for administering the test is supplied. "The examination shall be carried out, if possible, in full daylight. If urgently required, as for instance during the darkest months of the year, the test may be performed in the light of a really good, so-called daylight lamp." The observation distance is 50 to 75 mm, the time of exposition of each plate is not to exceed fifteen seconds, during which time the testee is permitted to outline the design if he hesitates to name it. Normal color sense is indicated by the successful reading or outlining of the figure or path in 17 plates and the failure to see any design on the dissimulation plates, failure to read 2 or more significant plates indicates defective color vision, failure to read only 1 plate indicates doubtful color vision, which calls for more detailed examination by other technics.

If a more exact specification of the amount and quality of the illumination under which the plates are to be administered had been made, the B-K series might have provided an interesting addition to the growing list of pseudoisochromatic tests. Because of the small size of the colored dots and their low chroma, this series appears on inspec-

tion to be a more rigid and sensitive test of color performance than are the series of Stilling, Ishihara and Rabkin and the plates compiled by the American Optical Company. It is probable that for many subjects who have been classified as having low normal color vision a diagnosis of defective color vision would have been made with the new Swedish plates. Particularly because of the higher sensitivity of the test, however, a more exact specification of the illuminant to be used should unquestionably have been made. The spectral composition of "full daylight" varies within wide limits, and any test which employs pigment stimuli is valid only when the color temperature of the illuminant for which it was designed is exactly specified and followed during the administration. Standard illuminants for color work were adopted in 1931 by the International Commission on Illumination, and today this type of specification is accepted as mandatory for the accurate testing of color vision with pigment stimuli.

GERTRUDE RAND

**Diseases of the Retina.** By Herman Elwyn, M.D. Price, \$10. Pp. 587 with 170 illustrations, 19 in color. Philadelphia: The Blakiston Company (Division of Doubleday & Company, Inc.), 1946.

During the past decade a most serious shortage in texts and monographs in the many special subdivisions of the general field of ophthalmology has developed in this country. This shortage has now become so severe that it is practically impossible for a young ophthalmologist to obtain an adequate work shelf of reference books. Part of the difficulty is attributable to the habit of dependence acquired long ago on the supply of such texts and monographs from European publishers. There has been no dearth of able and ambitious authors, but American publishers have been reluctant to undertake what was very likely to prove a losing venture. Some 150 new ophthalmologists are born into the profession in this country each year. Since books cannot be produced in editions of less than one to two thousand without excessive cost per copy, even the most successful text cannot be sold out in less than ten to fifteen years, and by that time progress in knowledge often demands considerable rewriting. Thus, the expectation of profit from reprinting is almost completely absent. Consequently the commercial publisher could hardly be expected to push this field unless he was prepared to compete for the international market.

Against this doleful background, the publication of Dr. Elwyn's excellent book on diseases of the retina is a potential harbinger of spring. Dr. Elwyn has already established himself as a competent and successful author by his book on nephritis, and he brings to his subject the rare combination of a thorough training in both ophthalmology and internal medicine. The book contains several novel and useful features of organization, such as the grouping together in one section the "diseases of the retina leading to retinal detachment," and has achieved an unusual compactness and coherence as the result of these innovations. It contains an unusually solid amount of histopathologic data, furnishing in their way an excellent foundation for the clinical evaluations. References to the modern literature have been chosen with much care,

affording the reader a well balanced approach to original articles, while avoiding the burdensome pedantry of an attempt at completeness which has, in the past, characterized many Continental texts. The illustrations, especially the drawings of the fundus, most of which have been reproduced from publications in the current literature, reflect the general improvement in this field during the past generation.

J. S. FRIEDENWALD

**Les aspects pathologiques du fond de l'oeil dans les affections de la rétine (atlas ophtalmoscopique)** By Gabriel Renard Pp 172, with 32 plates in colors Paris Masson & Cie, 1946

This is a continuation of the monographs on the ophtalmoscopic examination of the fundus oculi, which began with Professor Damis' excellent report on the "Normal Appearance and the Congenital Anomalies of the Eyeground," was published in 1940 and reviewed in the ARCHIVES (24:855 [Oct] 1940). Notwithstanding the difficulties of bringing out a satisfactory volume in the trying years that have just passed, the obstacles have been overcome, and this report was presented at the congress of the French Society of Ophthalmology in May 1946.

This volume brings pictures of various aspects of retinal contusion, two conditions peculiar to children, namely, glioma and hemorrhagic pachymeningitis, the macular hemorrhages associated with myopia, folds of the retina and angioid striae, Coats's retinitis and phakomatoses, familial degenerations, indefinite and senile macular changes, and, finally, isolated lesions of the retinal vessels, arterial obliteration, venous thrombosis and hemorrhages in the vitreous. The book aims at a complete illustration of a few diseases of the retina and is chiefly a clinical treatise. Treatment is omitted. Pathology is described only if it clarifies the clinical condition. There are 32 plates, with 60 pictures in color, comments are added to each observation, and there is a bibliography of 260 articles which should be of interest to the ophthalmologist. The colored drawings are excellent and are the work of Mlle Lalau.

While the list includes only a few of the lesions of the fundus, those portrayed are well selected and instructive. It is stated that additional drawings will appear in a future volume.

The author and the French Society of Ophthalmology are to be congratulated on the resumption of the publication of this interesting and important series, and it is to be hoped that future numbers will appear without interruption.

ARNOLD KNAPP.

**Eye Health: A Teaching Handbook for Nurses.** By Anna C Gring, R N, and Eleanor W Mumford, R N Price, \$0.60 Pp 108 New York: The National Society for the Prevention of Blindness, Inc, 1946

The National Society for the Prevention of Blindness, Inc, has brought out a small handbook of 108 pages for nurses who deal with eye health. Simple discussions of the following topics are given: anatomy and physiology of the eye, refraction and motor anomalies,



principles of lighting, simple examinations implied in the term "screening," causes of defective vision, the eyes in childhood and in adult life, and first aid care and treatment of injuries to the eyes

One cannot but feel that this is a rather formidable list of subjects for a small handbook and that the superficial knowledge conveyed will hardly fit the guise to answer questions for which training in medicine and in ophthalmology is required

1946 Year Book of Eye, Ear, Nose and Throat By Louis Bothman, M D, and Samuel J Crowe, M D Price, \$3.75 Pp 543 Chicago Year Book Publishers, Inc, 1946

In the 1946 Year Book of the Eye, Ear, Nose and Throat, Dr Louis Bothman, editor of the section on the eye, brings a special article on the medical treatment of glaucoma. A plea is made for the medical treatment of glaucoma, with the statement that the tension in many cases can be controlled with miotics, without serious loss of vision or fields, and that carbachol (an ophthalmic preparation of carbaminoylcholine chloride) is found to be a most satisfactory drug for the treatment of glaucoma. A complete survey then follows of the articles that have appeared in the ophthalmologic literature during the previous year, arranged according to the usual anatomic classification. Many of the articles are illustrated, and the editor has often added interesting and valuable comments from his own experience. Chapters on injuries and on surgical procedures are added, and under the title "General and Miscellaneous" the reader will find abstracts on general topics, such as vascular spasm, detergents, penetration of penicillin, dietary deficiency, alkali treatment of methyl alcohol poisoning, ocular intoxication by so-called green tobacco, use of antistin (an imidazole derivative) in ophthalmology, treatment of ocular syphilis with hyperpyrexia and malaria, tropical diseases, Reiter's disease, ocular leprosy, Behcet's disease and temporal arteritis.

This excellent treatise fulfils a definite want. The subjects are well covered, and the abstracting is well done. Dr Bothman deserves great credit for an interesting and valuable book, which can be confidently recommended.

ARNOLD KNAPP

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Secretary Dr Trygve Gundersen, 101 Bay State Rd, Boston  
Place Chicago Time June 21-25, 1948

## AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY, SECTION ON OPHTHALMOLOGY

President Dr Alan C Woods, Johns Hopkins Hospital, Baltimore 5  
President-Elect Dr C H McCaskey, 20 N Meridian St, Indianapolis, Ind  
Executive Secretary-Treasurer Dr William L Benedict, 100-1st Ave Bldg,  
Rochester, Minn  
Place Palmer House, Chicago Time Oct 12-17, 1947

## AMERICAN OPHTHALMOLOGICAL SOCIETY

President Dr John W Burke, 1740 M St N W, Washington, D C  
Secretary-Treasurer Dr Walter S Atkinson, 129 Clinton St, Watertown, N Y

## ASSOCIATION FOR RESEARCH IN OPHTHALMOLOGY, INC

Chairman Dr Derrick Vail, 55 E Washington St, Chicago 2  
Secretary-Treasurer Dr Brittain F Payne, 17 E 72d St, New York 2  
Assistant Secretary-Treasurer Dr Hunter Romain, 111 E 65th St, New York

## CANADIAN MEDICAL ASSOCIATION, SECTION ON OPHTHALMOLOGY

President Dr Alexander E MacDonald, 170 St George St, Toronto 5  
Secretary-Treasurer Dr L J Sebert, 170 St George St, Toronto 5

## CANADIAN OPHTHALMOLOGICAL SOCIETY

President Dr R J P McCulloch, 830 Medical Arts Bldg, Toronto 5  
Secretary-Treasurer Dr J F A Johnston, 174 St George St, Toronto 5

## NATIONAL SOCIETY FOR THE PREVENTION OF BLINDNESS

President Mr Mason H Bigelow, 1790 Broadway, New York 19  
Secretary Miss Regina E Schneider, 1790 Broadway, New York 19  
Executive Director Mrs Eleanor Brown Merrill, 1790 Broadway, New York

# SECTIONAL

## ACADEMY OF MEDICINE OF NORTHERN NEW JERSEY, SECTION ON EYE, EAR, NOSE AND THROAT

President Dr Anthony Ambrose, 31 Lincoln Park, Newark  
Secretary Dr W Franklin Kein, 15 Washington St, Newark 2  
Place 91 Lincoln Park South, Newark Time 8 45 p m, second Monday of  
each month, October to May

## CENTRAL ILLINOIS SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr Walter Stevenson, 510 Maine St, Quincy, Ill  
Secretary-Treasurer Dr William F Hubble, 877 Citizens Bldg, Decatur, Ill

## CENTRAL WISCONSIN SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr W S Jones, 521 Sheridan Rd, Menominee, Mich  
Secretary Dr G L McCormick, 650 S Central Ave, Marshfield

## HAWAII EYE, EAR, NOSE AND THROAT SOCIETY

President Dr Howard E Crawford, P O Box 1962, Hilo  
 Secretary-Treasurer Dr Tadao Hata, 1704 S King St, Honolulu  
 Place Pacific Club, Honolulu Time Third Thursday of each month

## NEW ENGLAND OPHTHALMOLOGICAL SOCIETY

President Dr Edwin B Dunphy, 243 Charles St, Boston  
 Secretary-Treasurer Dr Merrill J King, 264 Beacon St, Boston 16  
 Place Massachusetts Eye and Ear Infirmary, 243 Charles St, Boston Time  
 8 p m, third Tuesday of each month from November to April, inclusive

## PACIFIC COAST OTO-OPHTHALMOLOGICAL SOCIETY

President Dr D H O'Rourke, 1612 Tremont Pl, Denver  
 Secretary-Treasurer Dr C Allen Dickey, 450 Sutter St, San Francisco

## PUGET SOUND ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President Dr Walter C Camcron, 1103 Medical Arts Bldg, Tacoma, Wash  
 Secretary-Treasurer Dr Barton E Peden, 301 Stimson Bldg, Seattle 1, Wash  
 Place Seattle or Tacoma, Wash Time Second Tuesday of each month except  
 June, July and August

## ROCK RIVER VALLEY EYE, EAR, NOSE AND THROAT SOCIETY

President Dr Robert C Finger, RFD New Tower, Rockford, Ill  
 Secretary-Treasurer Dr Vernon C Völtz, 625 Gas-Electric Bldg, Rockford, Ill  
 Place Rockford, Ill, or Janesville or Beloit, Wis Time Third Tuesday of each  
 month from October to April, inclusive

## SAGINAW VALLEY ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr Harold H Houser, 207 Davidson Bldg, Bay City, Mich  
 Secretary-Treasurer Dr V E Cortopassi, 324 S Washington Ave, Saginaw,  
 Mich  
 Place Saginaw or Bay City, Mich Time Second Tuesday of each month, except  
 July, August and September

## SIOUX VALLEY EYE AND EAR ACADEMY

President Dr J C Decker, 515 Francis Bldg, Sioux City, Iowa  
 Secretary-Treasurer Dr J E Dvorak, 408 Davidson Bldg, Sioux City, Iowa

SOUTHERN MEDICAL ASSOCIATION, SECTION ON OPHTHALMOLOGY  
AND OTOLARYNGOLOGY

Chairman Dr Calhoun McDougall, Atlanta, Ga  
 Secretary Dr Alston Callahan, 908 S 20th St, Birmingham 5, Ala  
 Time First week in November

## SOUTHWESTERN ACADEMY OF EYE, EAR, NOSE AND THROAT

President Dr H L Brehmer, 221 W Central Ave, Albuquerque, N Mex  
 Secretary Dr A E Cruthrds, 1011 Professional Bldg, Phoenix, Ariz

## SOUTHWESTERN MICHIGAN TRIOLOGICAL SOCIETY

President Dr W M Dodge, 716 First National Bank Bldg, Battle Creek  
 Secretary-Treasurer D Kenneth Lowe, 25 W Michigan Ave, Battle Creek  
 Time Last Thursday of September, October, November, March, April and May

## WESTERN PENNSYLVANIA EYE, EAR, NOSE AND THROAT SOCIETY

President Dr J Paul McCloskey, 338 Locust St, Johnstown  
 Secretary-Treasurer Dr Fred E Murdock, 28½ W Scribner St, Dubois

STATE

ARKANSAS STATE MEDICAL SOCIETY, EYE, EAR, NOSE AND THROAT SECTION

President Dr E C Moulton, 619 Garrison Ave, Fort Smith  
Secretary Dr K W Cosgrove, 7 Urquhart Bldg, Little Rock

COLORADO OPHTHALMOLOGICAL SOCIETY

President Dr George H Stine, Burns Bldg, Colorado Springs  
Secretary Dr J Leonard Swigert, 320 Republic Bldg, Denver  
Place Colorado General Hospital Time 7 30 p m, third Saturday of each month, October to May, inclusive

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON EYE, EAR,  
NOSE AND THROAT

President Dr W H Turnley, 1 Atlantic St, Stamford, Conn  
Secretary-Treasurer Dr Morton B Arnold, 781 Main St, Williamantic, Conn

EYE, EAR, NOSE AND THROAT CLUB OF GEORGIA

President Dr William O Martin Jr, Doctors Bldg, Atlanta  
Secretary-Treasurer Dr C K McLaughlin, 666 Cherry St, Macon

INDIANA ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President Dr W E Stewart, 721 Wabash Ave, Terre Haute  
Secretary Dr Russell A Sage, 23 E Ohio St, Indianapolis

IOWA ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President Dr C S O'Brien, University Hospital, Iowa City  
Secretary-Treasurer Dr Carl A Noe, 120-3d Ave S E, Cedar Rapids

KANSAS STATE MEDICAL SOCIETY, SECTION ON OPHTHALMOLOGY  
AND OTOLARYNGOLOGY

President Dr W B Granger, Emporia  
Secretary Dr George F Gsell, 911 Beacon Bldg, Wichita 2

LOUISIANA-MISSISSIPPI OPHTHALMOLOGICAL AND OTOLARYNGOLOGICAL SOCIETY

President Dr George S Adkins, 121 N President St, Jackson, Miss  
Secretary-Treasurer Dr Edley H Jones, 1301 Washington St, Vicksburg, Miss

MEDICAL SOCIETY OF THE STATE OF PENNSYLVANIA, SECTION ON  
EYE, EAR, NOSE AND THROAT DISEASES

Chairman Dr William T Hunt Jr, 1205 Spruce St, Philadelphia 7  
Secretary Dr Gabriel Tucker, 250 S 18th St, Philadelphia 3

MICHIGAN STATE MEDICAL SOCIETY, SECTION OF OPHTHALMOLOGY  
AND OTOLARYNGOLOGY

Chairman Dr Ralph H Gilbert, 110 Fulton St E, Grand Rapids  
Secretary Dr Walter Z Rundles, 620 Maxine Ave, Grand Rapids  
Place Grand Rapids Time Sept 23-26, 1947

MINNESOTA ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr L R Boies, 1427 Medical Arts Bldg, Minneapolis  
Secretary Dr W L Hoffman, 543 Medical Arts Bldg, Minneapolis  
Place Minneapolis Club Time 6 00 p m, second Friday of each month from October to May



## MONTANA ACADEMY OF OTO-OPHTHALMOLOGY

President Dr H Casebeer, 44 W Park Ave, Butte  
 Secretary Dr Fritz D Hurd, 309 Medical Arts Bldg, Great Falls

## NEBRASKA ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr W Howard Morrison, 1500 Medical Arts Bldg, Omaha  
 Secretary-Treasurer Dr John Peterson, 1307 N St, Lincoln

NEW JERSEY STATE MEDICAL SOCIETY, SECTION ON OPHTHALMOLOGY,  
OTOLOGY AND RHINOLARYNGOLOGY

Chairman Dr C W Buvinger, 50 Washington St, East Orange  
 Secretary Dr Z Laurence Griesemer, 1145 E Jersey St, Elizabeth

NEW YORK STATE MEDICAL SOCIETY, EYE, EAR, NOSE AND  
THROAT SECTION

Chairman Dr Maxwell D Ryan, 660 Madison Ave, New York 21  
 Secretary Dr Thomas H Johnson, 30 W 59th St, New York

## NORTH CAROLINA EYE, EAR, NOSE AND THROAT SOCIETY

President Dr V K Hart, 106 W 7th St, Charlotte  
 Secretary Dr J A Harrill, Bowman Gray School of Medicine, Winston-Salem  
 Place Hendersonville Time Sept 15-18, 1947

## NORTH DAKOTA ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President Dr E D Perrin, 221-5th St, Bismarek  
 Secretary-Treasurer Dr M T Lampert, Minot

## OREGON ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President Dr Wilfred Belnap, 833 S W 11th Ave, Portland  
 Secretary-Treasurer Dr C W Kuhn, 1020 S W Taylor St, Portland 5  
 Place Good Samaritan Hospital, Portland Time Third Tuesday of each month

## PENNSYLVANIA ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr Gilbert L Dailey, Harrisburg  
 Secretary Dr Benjamin F Souders, 143 N 6th St, Reading  
 Time Last week in April

## RHODE ISLAND OPHTHALMOLOGICAL AND OTOLOGICAL SOCIETY

Acting President Dr N Darrell Harvey, 112 Waterman St, Providence  
 Secretary-Treasurer Dr Linley C Happ, 124 Waterman St, Providence  
 Place Rhode Island Medical Society, Library, Providence Time 8 30 p m,  
 second Thursday in October, December, February and April

## SOUTH CAROLINA SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr Ruskin Anderson, 145 N Converse St, Spartanburg  
 Secretary-Treasurer Dr Roderick Macdonald, 330 E Main St, Rock Hill  
 Place Hendersonville Time September, 1947

## TENNESSEE ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr George Burchfield, Maryville  
 Secretary-Treasurer Dr Sam H Sanders, 1089 Madison Ave, Memphis

## TEXAS OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

President Dr W E Vandevere, 1001 First National Bank Bldg, El Paso  
 Secretary Dr E D Dumas, 425 Medical Arts Bldg San Antonio  
 Place Houston Time December, 1947

UTAH OPHTHALMOLOGICAL SOCIETY

President Dr Charles Ruggeri Jr, 1120 Boston Bldg, Salt Lake City 1  
 Secretary-Treasurer Dr Robert G Snow, 202 E South Temple, Salt Lake City 2  
 Place University Club, Salt Lake City Time 7 00 p m, third Monday of  
 each month, September through May

VIRGINIA SOCIETY OF OTO-LARYNGOLOGY AND OPHTHALMOLOGY

President Dr Thomas E Hughes, 1000 W Grace St, Richmond  
 Secretary-Treasurer Dr Francis H McGovern, 105 S Union St, Danville

WEST VIRGINIA STATE MEDICAL ASSOCIATION, EYE, EAR, NOSE AND  
 THROAT SECTION

President Dr George Traugh, 309 Cleveland Ave, Fairmont  
 Secretary Dr Welch England, 621½ Market St, Parkersburg

LOCAL

AKRON ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr R F Thaw, 301 Ohio Bldg, Akron, Ohio  
 Secretary-Treasurer Dr J C Damitz, 2d National Bank Bldg, Akron 8, Ohio  
 Time 6 30 p m, first Monday in January, March, May and November

ATLANTA EYE, EAR, NOSE AND THROAT SOCIETY

President Dr William B Armstrong, 478 Peachtree St N E, Atlanta, Ga  
 Secretary Dr Lester A Brown, 815 Doctors Bldg, Atlanta, Ga  
 Place Academy of Medicine Time 7 00 p m, fourth Monday of each month  
 from October to May

BALTIMORE MEDICAL SOCIETY, SECTION ON OPHTHALMOLOGY

Chairman Dr Cecil H Bagley, 2 E Reed St, Baltimore  
 Secretary Dr F Edwin Knowles Jr, 513 N Charles St, Baltimore  
 Place Medical and Chirurgical Faculty, 1211 Cathedral St Time 8 30 p m.,  
 fourth Thursday of each month from October to March

BIRMINGHAM EYE, EAR, NOSE AND THROAT CLUB

President Each member, in alphabetical order  
 Secretary Dr W Chunn Parsons, 425 Woodward Bldg, Birmingham, Ala  
 Place Thomas Jefferson Hotel Time 6 30 p m, second Tuesday of each month,  
 September to May, inclusive

BROOKLYN OPHTHALMOLOGICAL SOCIETY

President Dr Benjamin C Rosenthal, 140 New York Ave, Brooklyn 16  
 Secretary-Treasurer Dr Louis Freimark, 256 Rochester Ave, Brooklyn 13  
 Place Towers Hotel, 25 Clark St Time 8 15 p m, third Thursday in February,  
 April, October and December

BUFFALO OPHTHALMOLOGIC CLUB

President Dr William H Howard, 389 Linwood Ave, Buffalo 9  
 Secretary-Treasurer Dr Sheldon B Freeman, 196 Linwood Ave, Buffalo 9  
 Time Second Thursday of each month from October to May

CENTRAL NEW YORK EYE, EAR, NOSE AND THROAT SOCIETY

President Dr Uri Doolittle, University Bldg, Syracuse  
 Secretary-Treasurer Dr Alfred W Doust, 306 State Tower Bldg, Syracuse  
 Place University Club Time 7 00 p m, second Wednesday

## CHATTANOOGA SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Each member, in alphabetical order

Secretary Dr Douglas Chamberlain, Providence Bldg, Chattanooga, Tenn

Place Mountain City Club Time Second Thursday of each month from September to May

## CHICAGO OPHTHALMOLOGICAL SOCIETY

President Dr W A Mann, 30 N Michigan Ave, Chicago 2

Secretary Dr J R Fitzgerald, 30 N Michigan Ave, Chicago 2

Place Continental Hotel, 505 N Michigan Ave Time Third Monday of each month from October to May

## CINCINNATI GENERAL HOSPITAL OPHTHALMOLOGY STAFF

Chairman Rotate alphabetically

Secretary Dr A A Levin, 441 Vine St, Cincinnati

Place Cincinnati General Hospital Time 7 45 p m, third Friday of each month except June, July and August

## CLEVELAND OPHTHALMOLOGICAL CLUB

Chairman Dr M Paul Motto, Rose Bldg, Cleveland

Secretary Dr H H Wygand, 624 Guardian Bldg, Cleveland

Time Second Tuesday in October, December, February and April

## COLLEGE OF PHYSICIANS, PHILADELPHIA, SECTION ON OPHTHALMOLOGY

Chairman Dr Burton Chance, 317 S 15th St, Philadelphia

Clerk Dr George F J Kelly, 37 S 20th St, Philadelphia

Place College of Physicians Bldg Time 8 15 p m, third Thursday of every month from October to April, inclusive

## COLUMBUS OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

Chairman Dr M Goldberg, 328 E State St, Columbus, Ohio

Secretary-Treasurer Dr W J Miller, 21 E State St, Columbus, Ohio

Place University Club Time 6 15 p m, first Monday of each month, from October to May, inclusive

## CORPUS CHRISTI EYE, EAR, NOSE AND THROAT SOCIETY

Chairman Dr Edgar Mathis, 815 Medical Professional Bldg, Corpus Christi, Texas

Secretary Dr June Yates, 210 Medical Professional Bldg, Corpus Christi, Texas

Place Nueces Hotel Time 6 30 p m, third Tuesday of each month from October to May

## DALLAS ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President Dr L Darrough, 4105 Live Oak St, Dallas, Texas

Secretary Dr C A Hoefler, 1719 Pacific Ave, Dallas 1, Texas

Place Dallas Athletic Club Time 6 30 p m, first Tuesday of each month from October to June The November, January and March meetings are devoted to clinical work

## DES MOINES ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr H I McPherrin, 406-6th Ave, Des Moines, Iowa

Secretary-Treasurer Dr C C Jones, 1110 Equitable Bldg, Des Moines, Iowa

Time 6 30 p m, fourth Monday of every month from September to May

DETROIT OPHTHALMOLOGICAL CLUB

Chairman Members rotate alphabetically  
 Secretary Dr Wesley G Reid, 974 Fisher Bldg, Detroit 2  
 Place Club rooms of Wayne County Medical Society Time Second Monday of  
 each month, November to April, inclusive

• DETROIT OPHTHALMOLOGICAL SOCIETY

President Dr Bruce Fralick, 201 S Main St, Ann Arbor, Mich  
 Secretary Dr William S Gonne, 619 David Whitney Bldg, Detroit 26  
 Place Hayler's L'Aiglon Bldg Time 6 30 p m, third Thursday of each month  
 from November to April, inclusive

EASTERN NEW YORK EYE, EAR, NOSE AND THROAT ASSOCIATION

President Dr Frank C Furlong, 713 Union St, Schenectady  
 Secretary-Treasurer Dr E Martin Freund, 762 Madison Ave, Albany  
 Time Third Wednesday in October, November, March, April, May and June

FORT WORTH EYE, EAR, NOSE AND THROAT SOCIETY

President Dr C R Lees, 602 W 10th St, Fort Worth 2, Texas  
 Secretary-Treasurer Dr Van D Rathgeber, 1305 Medical Arts Bldg, Fort  
 Worth, Texas  
 Place Tarrant County Medical Hall, Medical Arts Bldg Time 7 30 p m,  
 first Friday of each month except July and August

HOUSTON ACADEMY OF MEDICINE, OPHTHALMOLOGICAL AND  
 OTO-LARYNGOLOGICAL SECTION

President Dr J Matt Robison, 1304 Walker Ave, Houston, Texas  
 Secretary Dr John H Barrett, 1304 Walker Ave, Houston, Texas  
 Place River Oaks Country Club Time 6 30 p m, second Thursday of each  
 month from October to June

INDIANAPOLIS OPHTHALMOLOGICAL AND OTOLARYNGOLOGICAL SOCIETY

President Dr J Jerome Littell, 603 Hume Mansur Bldg, Indianapolis  
 Secretary Dr J Lawrence Sims, 23 E Ohio St, Indianapolis  
 Place Indianapolis Athletic Club Time 6 30 p m, second Thursday of each  
 month from November to May

KANSAS CITY SOCIETY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President Dr Walter L Small, 1103 Grand Ave, Kansas City, Mo  
 Secretary Dr John Clair Howard Jr, 1103 Grand Ave, Kansas City, Mo  
 Time Third Thursday of each month from October to June The November,  
 January and March meetings are devoted to clinical work

LONG BEACH EYE, EAR, NOSE AND THROAT SOCIETY

Chairman Dr Robert G Thornburgh, 117 E 8th St, Long Beach 2, Calif  
 Secretary-Treasurer Dr Kirt Parks, 605 Professional Bldg, Long Beach 2, Calif  
 Place Seaside Hospital Time Third Wednesday of each month from October to  
 May

LOS ANGELES SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr William D Donohue, Los Angeles  
 Secretary-Treasurer Dr K C Brandenburg, 110 Pine Ave, Long Beach 2, Calif  
 Place Los Angeles County Medical Association Bldg, 1925 Wilshire Blvd Time  
 6 00 p m, fourth Monday of each month from September to May, inclusive

## LOUISVILLE EYE AND EAR SOCIETY

President Dr Joseph S Heitger, Heyburn Bldg, Louisville, Ky  
 Secretary-Treasurer Dr J W Fish, 321 W Broadway, Louisville, Ky  
 Place Brown Hotel Time 6 30 p m, second Thursday of each month from  
 September to May, inclusive

## LOWER ANTHRACITE EYE, EAR, NOSE AND THROAT SOCIETY

Chairman Each member in alphabetical order  
 Secretary Dr James J Monohan, 31 S Jardin St, Shenandoah, Pa

MEDICAL SOCIETY OF THE DISTRICT OF COLUMBIA, SECTION OF  
OPHTHALMOLOGY AND OTOLARYNGOLOGY

Chairman Dr P S Constantinople, 1835 I St N W, Washington  
 Secretary Dr Frazier Williams, 1801 I St N W, Washington  
 Place 1718 M St N W Time 8 p m, third Friday of each month from October  
 to April, inclusive

## MEMPHIS SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

Chairman Each member, in alphabetical order  
 Secretary Dr Sam H Sanders, 1089 Madison Ave, Memphis, Tenn  
 Place Eye Clinic of Memphis Eye, Ear, Nose and Throat Hospital Time 8 p m,  
 second Tuesday of each month from September to May

## MILWAUKEE OTO-OPHTHALMIC SOCIETY

President Dr Meyer S Fox, 238 W Wisconsin Ave, Milwaukee  
 Secretary-Treasurer Dr Ralph T Rank, 238 W Wisconsin Ave Milwaukee  
 Place University Club Time 6 30 p m, fourth Tuesday of each month from  
 October to May

## MONTGOMERY COUNTY MEDICAL SOCIETY

Chairman Dr H V Dutrow, 1040 Fidelity Medical Bldg, Dayton, Ohio  
 Secretary-Treasurer Dr Maitland D Place, 981 Reibold Bldg, Dayton, Ohio  
 Place Van Cleve Hotel Time 6 30 p m, first Tuesday of each month from  
 October to June, inclusive

## MONTREAL OPHTHALMOLOGICAL SOCIETY

President Dr L F Badeaux, 502 Cherrier St, Montreal, Canada  
 Secretary Dr John V V Nicholls, 1414 Drummond St, Montreal, Canada  
 Time Second Thursday of October, December, February and April

## NASHVILLE ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

Chairman Dr M M Cullom, 700 Church St, Nashville, Tenn  
 Secretary Dr R E Sullivan, 432 Doctors Bldg, Nashville 3, Tenn  
 Place James Robertson Hotel Time 6 30 p m, third Monday of each month  
 from October to May

## NEW ORLEANS OPHTHALMOLOGICAL AND OTOLARYNGOLOGICAL SOCIETY

President Dr Charles A Bahn, Maison Blanche Bldg, New Orleans  
 Secretary Dr Mercer G Lynch, Ochsner Clinic, New Orleans  
 Place Charity Hospital Time 8 p m, first Tuesday of every month

## NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

Chairman Dr Guernsey Frey, New York  
 Secretary Dr Maynard Wheeler, 30 W 59th St, New York  
 Time 8 30 p m, third Monday of every month from October to May, inclusive

## NEW YORK SOCIETY FOR CLINICAL OPHTHALMOLOGY

President Dr Daniel Kravitz, 861 Park Pl, Brooklyn  
 Secretary Dr Leon Ehrlich, 211 Central Park W, New York  
 Place New York Academy of Medicine, 2 E 103d St Time 8 p m, first Monday  
 of each month from October to May, inclusive

OKLAHOMA CITY ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr S R Shaver, 117 N Broadway, Oklahoma City  
 Secretary Dr William Mussil, Medical Arts Bldg, Oklahoma City  
 Place University Hospital Time Second Tuesday of each month from September to May

OMAHA AND COUNCIL BLUFFS OPHTHALMOLOGICAL AND  
 OTO-LARYNGOLOGICAL SOCIETY

President Dr Lyman H Heine, Fremont, Neb  
 Secretary-Treasurer Dr W Howard Morrison, 1500 Medical Arts Bldg, Omaha 2  
 Place Omaha Club, 20th and Douglas Sts, Omaha Time 6 p m dinner, 7 p m  
 program, third Wednesday of each month from October to May

PASSAIC-BERGEN OPHTHALMOLOGICAL CLUB

President Dr Thomas Sanfacon, 340 Park Ave, Paterson, N J  
 Secretary-Treasurer Dr J Averbach, 435 Clifton Ave, Clifton, N J  
 Place Doctors Lounge, Paulsen Medical and Dental Bldg Time 8 p m, last  
 Tuesday of each month except June, July and August

PHILADELPHIA COUNTY MEDICAL SOCIETY, EYE SECTION

President Dr L Waller Deichler, 1930 Chestnut St, Philadelphia 3  
 Secretary Dr Robert T M Donnelly, 255 S 17th St, Philadelphia  
 Time First Thursday of each month from October to May

PITTSBURGH OPHTHALMOLOGICAL SOCIETY

President Dr Jay G Linn, Jenkins Arcade, Pittsburgh  
 Secretary Dr Robert J Billings, Jenkins Arcade, Pittsburgh  
 Place Pittsburgh Academy of Medicine Bldg Time Fourth Monday of each  
 month, except June, July, August and September

READING EYE, EAR, NOSE AND THROAT SOCIETY

President Dr Claude W Bankes, 212 N 6th St, Reading, Pa  
 Secretary Dr Paul C Craig, 232 N 5th St, Reading, Pa  
 Place Wyomissing Club Time 6 30 p m, third Wednesday of each month  
 from September to July

RICHMOND EYE, EAR, NOSE AND THROAT SOCIETY

President Dr Edgar Childrey Jr, Professional Bldg, Richmond, Va  
 Secretary Dr Clifford A Folkes, Professional Bldg, Richmond, Va.  
 Place Commonwealth Club Time 6 p m, first Tuesday of January, March,  
 May and October

ROCHESTER EYE, EAR, NOSE AND THROAT SOCIETY

President Dr Frank Barber, 75 S Fitzhugh St, Rochester, N Y  
 Secretary-Treasurer Dr Charles T Sullivan, 277 Alexander St, Rochester, N Y

ST LOUIS OPHTHALMIC SOCIETY

President Dr A Lange, 3903 Olive St, St Louis  
 Secretary Dr William Klemberg, Frisco Bldg, St Louis  
 Place McMillan Hospital Time Fourth Friday of each month from October  
 to April, inclusive, except December, at 8 00 p m

SAN ANTONIO OPHTHALMO-OTO-LARYNGOLOGICAL SOCIETY

President Dr James P Aderhold, Medical Arts Bldg, San Antonio, Texas  
 Secretary-Treasurer Dr Virgil S Steele, South Texas Bldg, San Antonio, Texas  
 Place San Antonio Texas, and Brooke General Hospital Time 7 p m, second  
 Tuesday of each month from September to May

SAN FRANCISCO COUNTY MEDICAL SOCIETY, SECTION ON EYE,  
EAR, NOSE AND THROAT

Chairman Dr C B Cowan, 490 Post St, San Francisco  
Secretary Dr D Harrington, 384 Post St, San Francisco  
Place Society's Bldg, 2180 Washington St, San Francisco Time Fourth  
Tuesday of every month except June, July and December

SHREVEPORT EYE, EAR, NOSE AND THROAT SOCIETY

President Dr David C Swearingen, Slattery Bldg, Shreveport, La  
Secretary-Treasurer Dr Kenneth Jones, Medical Arts Bldg, Shreveport, La  
Place Shreveport Charity Hospital Time 7 30 p m, first Monday of every  
month except July, August and September

SPOKANE ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President Dr Robert L Polil, 762 Paulsen Medical and Dental Bldg, Spokane,  
Wash  
Secretary Dr Malcolm N Wilmes, 960 Paulsen Medical and Dental Bldg,  
Spokane, Wash  
Place Doctors Lounge, Paulsen Medical and Dental Bldg Time 8 p m, last  
Tuesday of each month except June, July and August

SYRACUSE EYE, EAR, NOSE AND THROAT SOCIETY

President Dr A H Rubenstein, 713 E Genesee St, Syracuse, N Y  
Secretary-Treasurer Dr I H Blaisdell, 713 E Genesee St, Syracuse, N Y  
Place University Club Time First Tuesday of each month except June, July  
and August

TOLEDO EYE, EAR, NOSE AND THROAT SOCIETY

Chairman Dr W W Randolph, 1838 Parkwood Ave, Toledo 2, Ohio  
Secretary Dr John L Roberts, 316 Michigan St, Toledo, Ohio  
Place Toledo Club Time 6 30 p m, each month except June, July and August

TORONTO ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

Chairman Dr R G C Kelly, 14 Lynwood Ave, Toronto 5, Canada  
Secretary Dr J C McCulloch, 830 Medical Arts Bldg, Toronto 5, Canada  
Place Academy of Medicine, 288 Bloor St W Time First Monday of each  
month, November to April

WASHINGTON, D C, OPHTHALMOLOGICAL SOCIETY

President Dr Richard W Wilkinson, 1408 L St N W, Washington, D C  
Secretary-Treasurer Dr Jerome A Sansoucy, 2017 Massachusetts Ave N W,  
Washington, D C  
Place Medical Society of District of Columbia Bldg, 1718 M St N W, Wash-  
ington, D C Time 7 30 p m, first Monday of each month from November  
to May

WILKES-BARRE OPHTHALMOLOGICAL SOCIETY

Chairman Each member in turn  
Secretary Dr Samuel T Buckman, 70 S Franklin St, Wilkes-Barre, Pa  
Place County Medical Society Library Time Last Tuesday of each month  
from October to May

## AUTONOMIC NERVOUS SYSTEM AND ACTION OF DRUGS IMPORTANT IN OPHTHALMOLOGY

H B VAN DYKE, M D  
NEW YORK

THE IMPORTANCE of the autonomic nervous system needs little emphasis. It regulates the essential involuntary activities of the body. These include such varied functions as respiration, the circulation of the blood, digestion, metabolism, heat regulation and control of glands of internal secretions so far as these are under nervous control. If the acetylcholine theory of neuromyal transmission is completely adopted, even the voluntary musculature can be considered closely related to the autonomic nervous system. For an understanding of the pharmacology of autonomic drugs important in ophthalmology, it seems desirable to include a discussion of the general pharmacology of the whole autonomic system, in or from which, according to modern theory, nerve impulses are transmitted by a humoral mechanism. The transmitting substances are believed to be acetylcholine (synaptic transmission in the central nervous system [?] and in all autonomic ganglions, neuromyal transmission in striated muscle, transmission from postganglionic parasympathetic fibers to effector cells) and epinephrine or the closely related sympathins (transmission from postganglionic sympathetic fibers to effector cells).

Recently, the concept of cholinergic neurohumoral transmission has been questioned by Nachmansohn,<sup>1</sup> who expressed the belief that acetylcholine is concerned only in conduction. He remarked

Cole and Curtis have shown by alternating current impedance measurements that the action potential is associated with a transient change in resistance which falls from 1000 ohm per cm<sup>2</sup> to 25 ohm. It is conceivable that a substance which appears and disappears within milliseconds could be responsible for these changes. The depolarization may be caused by the release of ACh at the point where the stimulus reaches the surface of the membrane. Thus, flow of current is generated to this point from the adjacent regions. This flow of current acts as stimulus of the next section and releases ACh there. The same process is repeated and thus the impulse is conducted along the fiber. This idea is quite compatible with the concept of propagated impulses as developed by Keith Lucas and Adrian. The

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<sup>1</sup> Nachmansohn, D. The Role of Acetylcholine in the Mechanism of Nerve Activity, in Harris, R. S., and Thimann, K. V. Vitamins and Hormones, New York, Academic Press, Inc., 1945, vol. 3, pp. 337-377



polarized state is rapidly restored by the removal of the free ester by its hydrolysis. At the nerve ending where the surface increases and therefore the resistance decreases this process would lead to a greater flow of current, thus enabling the impulse to cross the non-conducting gap.

In the original theory, ACh liberated at the nerve ending acts as "humoral" or "neurohumoral" transmitter directly on the effector organ or on the second neuron. According to the new concept, the release of ACh is an intracellular process generating flow of current by action on the cell membrane, but the transmitting agent is the flow of current. As outlined above, the electrical signs of nerve activity do not justify the assumption of a special mechanism responsible for transmission at synapses.

One frequently cited objection to Nachmansohn's theory is the failure to implicate acetylcholine in conduction along sensory nerves or sympathetic nerves. An even more serious discrepancy is the failure of anticholinesterases to alter conduction, as reported by Crescitelli, Koelle and Gilman<sup>2</sup>. These authors found that complete destruction of cholinesterase by diisopropyl fluorophosphate failed to interfere with nerve conduction. Yet such interference should be found according to Nachmansohn's theory, since conduction should be associated with extremely rapid destruction of the transiently formed acetylcholine. Rothenberg and Nachmansohn<sup>3</sup> disagreed with the conclusions of Crescitelli, Koelle and Gilman.

Eccles<sup>4</sup> proposed an alternative electrical hypothesis to explain synaptic and neuromuscular transmission but admitted that this hypothesis "will have to stand up to many severe tests, particularly pharmacologically."

For the purposes of this discussion, the older view that transmission of impulses depends on humoral agents, such as acetylcholine and substances closely related to epinephrine, will be adopted, since such a systematic approach is supported by a large body of experimental data and a consistent picture of the mechanism of action of drugs affecting the autonomic nervous system can be drawn. However, in view of recently expressed opinions to the contrary, the reader should recognize the biased approach adopted by the reviewer.

#### GENERAL ANATOMY AND PHARMACOLOGY OF THE AUTONOMIC NERVOUS SYSTEM

Anatomically, the various divisions of the autonomic nervous system proper consist of three main divisions. The afferent portion consists of

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2 Crescitelli, F., Koelle, G. B., and Gilman, A. Nerve Conduction in the Absence of Cholinesterase Activity Induced by Di-Isopropyl Fluorophosphate, *Federation Proc.* **5** 172, 1946.

3 Rothenberg, M. A., and Nachmansohn, D. On the Permeability of the Nerve Axon to Di-Isopropylfluorophosphate, *Federation Proc.* **5** 199-200, 1946.

4 Eccles, J. C. An Electrical Hypothesis of Synaptic and Neuromuscular Transmission, *Nature*, London **156** 680-683, 1945.

medullated fibers, which may make up a large proportion of a given autonomic nerve. Unfortunately, information on the importance of these afferent fibers—however great that importance may be—is restricted. In the central nervous system there are integrating structures at all levels, not only in the spinal cord but also in the medulla, in the mid-brain and hypothalamus and in the cerebral cortex. The third, or efferent, division is the one most accessible for investigation. It is natural, therefore, that the most precise information concerns the distribution and functions of this portion. In the efferent autonomic nervous system, there is one ganglionic synapse between the central nervous system and the effector cell. Unlike the cells of the skeletal musculature, these effector cells can still function fairly adequately after the postganglionic fiber has been severed, although the disturbance which occurs after denervation is more pronounced in the parasympathetic division than in the sympathetic division, owing to the greater importance of the former. It is also characteristic of denervated autonomically innervated structures that their susceptibility to drugs may be markedly increased.

Some generalizations can be made concerning anatomic and physiologic differences between sympathetic and parasympathetic efferent divisions. The intervening ganglion cell is often close to the viscus on the parasympathetic side, whereas on the sympathetic side the intervening ganglion cell is far from the viscus. A single axon entering a sympathetic ganglion may transmit impulses to a number of ganglionic neurons, whereas in parasympathetic ganglions each neuron more often receives the transmitted nerve impulse from a single axon. Hence the response of the sympathetic system tends to be diffuse, in contrast with the more localized and precise response of the parasympathetic nervous system. It is also well to remember that the question of innervation of the cells of a single structure supplied by the sympathetic and the parasympathetic fibers is not clear. It appears likely that no single cell has a dual innervation. The number of fibers supplying a given effector cell varies greatly. For example, smooth muscle cells may receive fibers only occasionally, whereas each cell of the ciliary muscle has its individual nerve supply.

No effort will be made to describe in any detail the anatomic divisions of the autonomic nervous system. It will be recalled that the sympathetic nerves arise from the intermediolateral region of the gray matter of the spinal cord from the seventh cervical segment to the third lumbar segment inclusive. The ganglions of the sympathetic system are of three types: the vertebral ganglions in the thoracic and lumbar regions, in close proximity to the spinal column, the large prevertebral ganglions, such as the celiac ganglion and the superior mesenteric gan-

gion (the inferior mesenteric ganglion is seen much more frequently in lower animals than in man), and, lastly, the visceral ganglions, sometimes lying in the wall of the viscus. The parasympathetic division is composed of nerves of cranial origin, as well as nerves derived from the second to the fourth sacral segment of the spinal cord. Four cranial nerves give off branches which are classified as parasympathetic branches of the third nerve, arising in the midbrain, branches of the seventh nerve supplying the submaxillary gland, as the chorda tympani, and the lacrimal gland, as the vidian nerve, the branch of the ninth nerve passing to the otic ganglion and thence to the parotid gland, and the important vagus nerve, which innervates numerous viscera in the thorax and abdomen.

Excellent reviews of the experimental basis for the theory of neuro-humoral transmission of nerve impulses are available, and one of the most recent, which is highly recommended to the ophthalmologist, is that of Loewi.<sup>5</sup> To the other pioneer investigator in this field, H. H. Dale, are owed the generally adopted adjectives adrenergic and cholinergic, to identify the transmitting substance as either epinephrine or acetylcholine without regard to strict anatomic origin.<sup>6</sup> (Particularly in the sympathetic division is there frequently cholinergic transmission.) It appears that epinephrine is the common agent transmitting sympathetic adrenergic impulses. However, Cannon and his collaborators expressed the belief that it (substance M) combines at the site of action with one of two other substances to form sympathin E or sympathin I according to whether the response is excitation or inhibition.<sup>7</sup>

Adrenergic transmission is characteristic of all sympathetic post-ganglionic efferent sympathetic nerves except the following, in which the mechanism is cholinergic:

- 1 Vasodilator nerves (except those of the coronary arteries and part of the arterial supply of skeletal muscle)
- 2 Sympathetic nerves to the sweat glands
- 3 Sympathetic nerves to the adrenal medulla (These nerves should be classified as preganglionic fibers, since the chromaffin cells of the adrenal medulla are analogous to sympathetic ganglion cells elsewhere.)

Cholinergic transmission, which is here considered as neurohumoral transmission the humoral moiety of which is acetylcholine, is responsible for transmission in the following structures:

5 Loewi, O. Aspects of the Transmission of the Nervous Impulse, *J. Mt. Sinai Hosp.* **12** 803-816 and 851-865, 1945.

6 Dale, H. H. Nomenclature of Fibres in the Autonomic Nervous System and Their Effects, *J. Physiol.* **80** 10P-11P, 1934.

7 Cannon, W. B., and Rosenblueth, A. Sympathin E and Sympathin I, *Am. J. Physiol.* **104** 557-574, 1933.

- 1 All synaptic transmission in autonomic ganglions (nicotinic effect of acetylcholine)
- 2 All transmission from the end plate of skeletal nerves to skeletal muscle (nicotinic effect)
- 3 Transmission from all parasympathetic postganglionic efferent fibers to the corresponding end organ (muscarinic effect)
- 4 Neurohumoral transmission by certain postganglionic efferent sympathetic nerves, such as vasodilator nerves and the nerves to sweat glands (muscarinic effect)

Much work has been undertaken to determine whether acetylcholine is concerned in synaptic transmission in the central nervous system. The available evidence so far does not permit any conclusion, although considerable data suggest that the central nervous system contains only true cholinesterase, so that it may be presumed that acetylcholine is formed in connection with central nervous activity and that the cholinesterase there present is available for its rapid hydrolysis.

It is likely that the transmitting agent, whether epinephrine or acetylcholine, exists in a bound, nondiffusible form, from which extremely rapid liberation occurs during nerve stimulation. The rapidity of release probably varies. For example, acetylcholine is much more rapidly released and destroyed in junctional transmission in synapses or in neuromyal transmission in skeletal muscle—both “nicotinic” in character—than in the “muscarinic” type of response evoked when postganglionic parasympathetic fibers are excited.

#### ACTION OF AUTONOMIC DRUGS IMPORTANT IN OPHTHALMOLOGY

Some information concerning the formation and destruction of the transmitting agents is available. The findings are important for an understanding of the action of adrenergic drugs, like cocaine and possibly ephedrine and related compounds, as well as of cholinergic drugs, like physostigmine and neostigmine. For the purposes of this discussion, epinephrine will be considered the important agent for adrenergic transmission, although Cannon and his co-workers have concluded that the primary, or common, transmitting agent (substance M, or epinephrine) is further modified, depending on the response of the innervated structure. The principal enzymes which have been implicated in the destruction of epinephrine are amine oxidase and catechol (pyrocatechol) oxidase. Inhibition of the destructive action of amine oxidase appears best to explain the sympathomimetic action of cocaine, which is believed to compete with epinephrine as a substrate for amine oxidase. Thus, locally liberated epinephrine will not undergo its normal rapid destruction but will act long and persistently. This mechanism makes intelligible the mydriatic effect of cocaine, as well as its sensitizing or potentiating

action if epinephrine is applied locally or administered systemically after or with cocaine. Gaddum has strongly advocated the view that ephedrine behaves similarly and that part of its sympathomimetic action is thus to be explained. It is likewise possible that related compounds, such as amphetamine ("benzedrine") and desoxyephedrine in part owe their sympathomimetic effects to competitive binding of amine oxidase.

Epinephrine can be regarded as the truest sympathomimetic drug. It acts on the sympathetically innervated cell and evokes a response identical with that of electrical stimulation of sympathetic nerves. All the synthetic related compounds differ slightly or greatly from epinephrine either in potency or in qualitative action or in both. Those drugs which are also potentiated by cocaine, such as "arterenol" (3, 4-dihydroxyphenylaminoethanol) or "corbasil" (3, 4-dihydroxyphenylaminopropanol), probably resemble epinephrine most closely pharmacologically. According to available evidence, two sympathomimetic drugs used in ophthalmology, "neo-synephrine hydrochloride" and paredrine (p-hydroxy- $\alpha$ -methylphenylethylamine), are likewise best classified as sympathomimetic stimulating agents. Lastly, although it was suggested in the foregoing paragraph that ephedrine, amphetamine and desoxyephedrine may, like cocaine, inhibit the enzymic destruction of epinephrine, their action is not as clearly limited to this mechanism, in part they probably directly stimulate some, but not all sympathetically innervated structures.

Much more accurate information is available concerning acetylcholine, the agent responsible for neurohumoral transmission in autonomic ganglions, from skeletal nerves to muscle and from postganglionic parasympathetic nerves to their end organs. Although drugs are not known to affect the formation of acetylcholine, it is of interest to record that Nachmansohn and Machado<sup>8</sup> have shown that an enzyme in the central nervous system which they named choline acetylase can bring about synthesis of this transmitting agent. There are required not only the enzyme but also choline, acetate, adenosine triphosphate and an optimum concentration of potassium. The enzymic acetylation of choline is an anaerobic process which so far has been shown to occur only in nerve tissue. Presumably after formation acetylcholine is bound in some nondiffusible form, from which it is liberated during nervous activity. In the scheme of acetylcholine formation just described an optimum concentration of potassium was mentioned. This cation is an important factor in nervous activity. Appropriate doses of potassium cause the liberation of acetylcholine from ganglion cells or of epinephrine from the adrenal glands. The cation, however, is not the mediator of adrenergic transmission, as has been maintained by some workers.

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<sup>8</sup> Nachmansohn, D, and Machado, A. L. The Formation of Acetylcholine A New Enzyme, Choline Acetylase, *J Neurophysiol* 6: 397-403, 1943.

More pertinent to this discussion is the manner in which certain drugs prevent the hydrolysis of acetylcholine. This destruction is ordinarily effected by cholinesterase, an enzyme found in nerve tissue and, paradoxically, also in erythrocytes. (There are also a number of nonspecific esterases in serum and tissues, which vary in the rate at which they hydrolyze acetylcholine.) Cholinesterase as well as nonspecific esterases are markedly inhibited both by physostigmine and by neostigmine. Carbaminoylcholine can also inhibit the action of cholinesterase. Of great interest is the destructive action of diisopropyl fluorophosphate (DFP) on cholinesterase, which apparently is irreversibly inactivated by this enzyme poison. The antiesterase effect of physostigmine, neostigmine and DFP explains the parasympathomimetic actions of these compounds, so that they are pharmacologically comparable to cocaine, which is a sympathomimetic agent by virtue of its inhibition of amine oxidase, an enzyme-destroying epinephrine.

The antiesterase effect of physostigmine, neostigmine and DFP permits locally formed acetylcholine to produce continuous and cumulative "stimulation" of the cells on which this transmitting agent acts. Although physostigmine and DFP would have no action were acetylcholine not liberated and of themselves cannot excite cells under the control of cholinergic nerves, it has recently been reported that neostigmine not only inactivates cholinesterase but also stimulates effector cells with a cholinergic innervation<sup>9</sup>. Riker and his colleagues also pointed out, as has already been mentioned, that carbaminoylcholine, particularly among synthetic choline esters, can inhibit cholinesterase. One of the most interesting antiesterases is diisopropyl fluorophosphate (DFP), which irreversibly destroys cholinesterase and other esterases. Its persistent and remarkable cholinergic effects in the normal or the glaucomatous human eye<sup>10</sup> are to be attributed to normally liberated acetylcholine, the action of which persists because the enzyme responsible for its hydrolysis has been destroyed.

Other parasympathomimetic drugs act only or principally as agents stimulating cells normally thus affected by impulses transmitted from postganglionic parasympathetic nerves. The normal transmitting agent, acetylcholine, is too rapidly hydrolyzed by the abundant amounts of cholinesterase and other esterases ordinarily present to be of any practical value as a parasympathomimetic drug. However, one of its congeners, carbaminoylcholine chloride ("carbachol") not only is not destroyed by cholinesterase but actually inhibits the enzyme. It is also probably a parasympathomimetic stimulant. Another synthetic relative of acetyl-

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9 Riker, W. F., Wescoe, W. C., Cattell, McK., and Shorr, E. The Mechanism of Action of Prostigmine, *Federation Proc.* 5:198-199, 1946.

10 Leopold, I. H., and Comroe, J. H. The Effects of Di-Isopropyl Fluorophosphate upon Normal and Glaucomatous Eyes, *Federation Proc.* 5:190, 1946.

choline, acetyl- $\beta$ -methylcholine ("mecholyl") is less readily hydrolyzed by cholinesterase than is acetylcholine. Acetyl- $\beta$ -methylcholine is thus a more persistent parasympathomimetic agent than acetylcholine but cannot approach carbaminoylcholine in this respect. At least in the eye, pilocarpine behaves like acetylcholine and in exciting the circular smooth muscle of the ciliary body and the iris acts analogously to the normal neurohumoral transmitter.

The drugs which remain to be considered are those paralyzing effector cells innervated by postganglionic parasympathetic fibers (Drugs like ergotoxine or ergotamine having in part a similar action on sympathetically innervated structures, have little apparent value to the ophthalmologist.) The important group paralyzing the muscarinic effects of acetylcholine in the eye, comprising drugs like atropine, homatropine, eucatropine (euphthalmine), scopolamine and duboisine, vary in potency and persistence of action. They do not interfere with the liberation of acetylcholine, nor do they facilitate its hydrolysis, they act by denying acetylcholine or a drug like pilocarpine access to the irritable "patches" of effector cells, where it is believed the response of the cells begins. Perhaps a drug like atropine, one of the most persistent and active members of this group, combines more firmly and less reversibly with an important constituent of the irritable "patches" of cell surfaces than transiently acting drugs, like homatropine. The "patches" may thus be rendered incapable of combination with or response to either acetylcholine or pilocarpine. The antagonism of physostigmine by atropine or related drugs is in reality an antagonism of atropine toward acetylcholine protected from hydrolysis by physostigmine inhibition of cholinesterase. Some drugs, such as carbaminoylcholine are much less effectively counteracted by atropine. Homatropine and eucatropine (euphthalmine), as well as the less important other members of the group, resemble atropine pharmacologically, although there are quantitative differences in action. It is well known that the effects of homatropine are much less persistent and that eucatropine, while causing mydriasis has little effect on accommodation.

#### SUMMARY

The outline which follows is restricted to drugs which are used in ophthalmology or are believed to be potentially useful (e g, DFP). Some which are included for completeness (e g, scopolamine and duboisine) are considered by the reviewer to be superfluous except when drug idiosyncrasy is present. Inability to explain drug action rigidly is reflected in the duplicate classifications of ephedrine, amphetamine, neostigmine and "carcholine."

- I Drugs acting on the adrenergic postganglionic nerves of the sympathetic division

- A Enzyme-inhibitors preventing the destruction of epinephrine, which is essential for neurohumoral transmission in this division. The locally produced epinephrine thus has a prolonged effect
    - 1 Cocaine
    - 2 Ephedrine (?)
    - 3 Amphetamine ("benzedrine") (?)
  - B Drugs acting on effector cells so as to mimic the action of the neurohumoral transmitter
    - 1 Epinephrine ("adrenalin")
    - 2 "Neo-synephrine hydrochloride"
    - 3 Paredrine
    - 4 Ephedrine
    - 5 Amphetamine ("benzedrine")
- II Drugs acting on cholinergic postganglionic nerves, which in the eye are parasympathetic
- A Inhibitors of the enzyme cholinesterase, which normally hydrolyzes the neurohumoral transmitting agent acetylcholine. The action of the locally produced acetylcholine is therefore markedly prolonged
    - 1 Physostigmine
    - 2 Neostigmine
    - 3 Diisopropyl fluorophosphate (DFP)
    - 4 Carbaminoylcholine hydrochloride ("carbacholine")
  - B Drugs acting on effector cells so as to mimic the action of acetylcholine, the neurohumoral transmitter
    - 1 Pilocarpine
    - 2 Neostigmine (?)
    - 3 Synthetic choline esters, such as carbaminolcholine
  - C Drugs producing varying degrees of paralysis of effector cells to impulses from parasympathetic postganglionic nerves or to stimulation by drugs like pilocarpine. These paralyzing drugs prevent the access of acetylcholine or stimulating drug to the irritable patches of the surface of effector cells
    - 1 Atropine
    - 2 Homatropine
    - 3 Eucatropine (euphthalmine)
    - 4 Scopolamine
    - 5 Duboisine



## SOFT GLAUCOMA AND CALCIFICATION OF THE INTERNAL CAROTID ARTERIES

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SINCE Fuchs's<sup>1</sup> paper in 1911, cases have been described with atrophy of the optic nerve, suggestive glaucomatous cupping and loss of visual field. The condition in these cases resembles chronic glaucoma but does not show elevation of intraocular pressure. It has been described by such terms as "soft glaucoma" and "glaucoma without hypertension."

In 1932 Knapp<sup>2</sup> reviewed the literature on this subject and described 10 cases of his own. All his cases were characterized by atrophy of the optic nerve with shallow cupping, defects of the visual fields which tended toward altitudinal hemianopsia and persistently normal tension. He was able to demonstrate roentgenographically calcification of the arteries at the base of the brain in all 10 cases. In 9 of these cases the internal carotid arteries were involved, either with or without involvement of other vessels in that region. He concluded that "the roentgen findings, not as yet confirmed by anatomic examination, suggest a possible cause." In 1940 Knapp<sup>3</sup> published a follow-up report on these cases. In most of them progress of the altitudinal field defects had been slow. Tension had remained normal or nearly normal. The loss in visual acuity and visual fields was out of proportion to the tension in the cases in which there had been slight elevations of intraocular pressure. In discussion of these cases, the rather common occurrence of calcification of the carotid artery in elderly persons with arteriosclerosis was noted and the incidence given as 1 in 8 persons.<sup>4</sup>

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Read at a meeting of the New York Academy of Medicine, Section of Ophthalmology, April 15, 1946

1 Fuchs, E. *Ztschr f Augenh* 25 108, 1911

2 Knapp, A. Association of Sclerosis of the Cerebral Basal Vessels with Optic Atrophy and Cupping, *Arch Ophth* 8 637 (Nov) 1932

3 Knapp, A. Course in Certain Cases of Atrophy of the Optic Nerve with Cupping and Low Tension, *Arch Ophth* 23 41 (Jan) 1940

4 Glee, M., 1936, cited by Knapp<sup>3</sup>

over the age of 50 and as 50 per cent of persons<sup>5</sup> over the age of 60. The suggestion is made<sup>6</sup> that damage to the optic nerve is caused by impairment of the small nutrient vessels of the nerve, rather than sclerosis and calcification of the carotid artery itself.

The case to be reported here belongs to this syndrome and is of interest because the mechanism of the disease process is demonstrated anatomically in the living patient.

#### REPORT OF A CASE

M S, a white man aged 61, had first noticed slight cloudiness of vision in 1935. At that time he consulted an ophthalmologist, who made a diagnosis of early glaucoma and prescribed pilocarpine. The next year he consulted another ophthalmologist, who assured him that he did not have glaucoma. In 1937 he

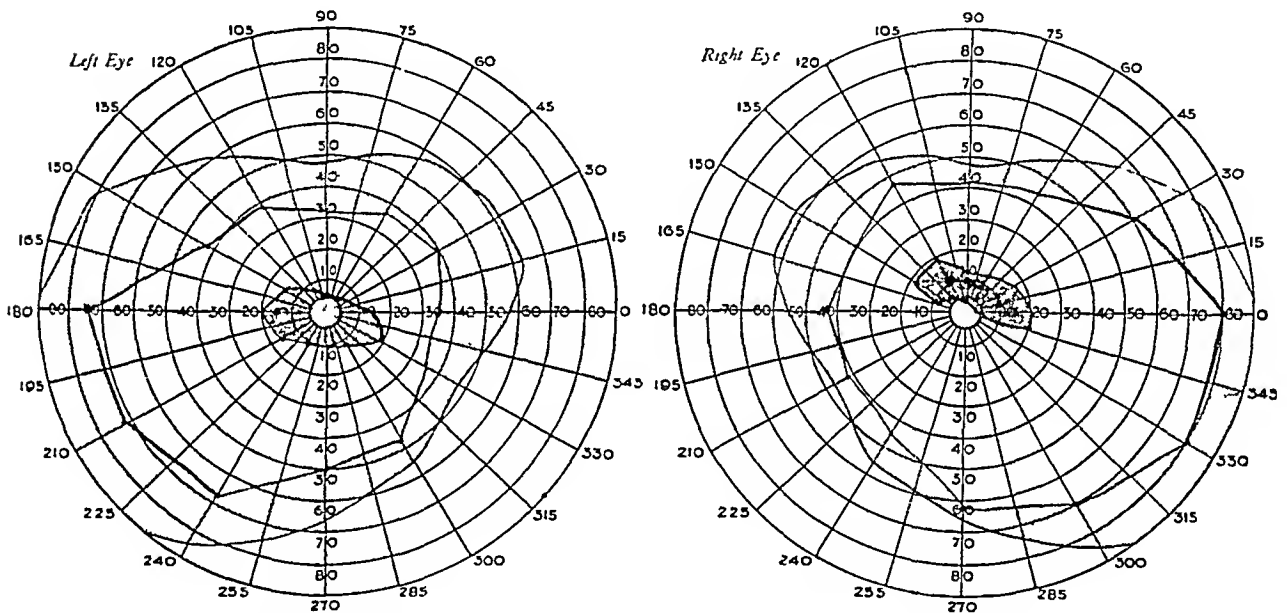


Fig 1—Visual fields in 1939 (courtesy of Dr B Samuels)

consulted several more ophthalmologists, from New York to California, and received varying opinions about the diagnosis of glaucoma. At no time was there any pain or redness of either eye or any iridescent vision. Tension had always been normal. Miotic therapy was continued. In 1939 an iridectomy was performed on the left eye by Dr Bernard Samuels. Visual fields taken at that time are shown in figure 1. Corrected visual acuity was 20/20 in the right eye and 1/200 in the left eye. After operation the tension remained normal in both eyes with continued slow loss of visual acuity and visual field. In 1945 the patient consulted two other ophthalmologists in New York. One of them made a diagnosis of glaucoma on a "toxic" basis, the other, after extensive study and provocative tests, stated that there was no glaucoma. With this conflict in opinions, the patient consulted Dr Alan Woods, of Baltimore, who found no evidence of glaucoma and referred him to us for study.

5 Siegert, P, 1938, cited by Knapp<sup>3</sup>

6 Best, F, 1931, cited by Knapp<sup>3</sup>

We first saw the patient on Dec 5, 1945. On that date his corrected visual acuity was 20/70 in the right eye and 3/200 in the left eye. Except for an operative coloboma of the iris of the left eye, both eyes appeared normal for a person of his age on external examination. Tension was 22 mm in the right eye and 18 mm in the left eye with a McLean tonometer (lower range of normal). On ophthalmoscopic examination, the right optic disk showed moderate pallor with shallow, incomplete cupping, without undermining and not appearing of glaucomatous type. The left optic disk was extremely pale, with similar cupping. The retinal vessels showed only mild sclerotic changes. The fundi were otherwise not remarkable. Biomicroscopic examination disclosed gerontoxon, slight peripheral, superficial atrophy of the iris, early nuclear sclerosis of the lenses, more advanced on the left, and a cleancut coloboma of the iris of the left eye without synechias. There was no evidence of inflammatory disease. Gonioscopic examination revealed an essentially normal condition with only a few postoperative

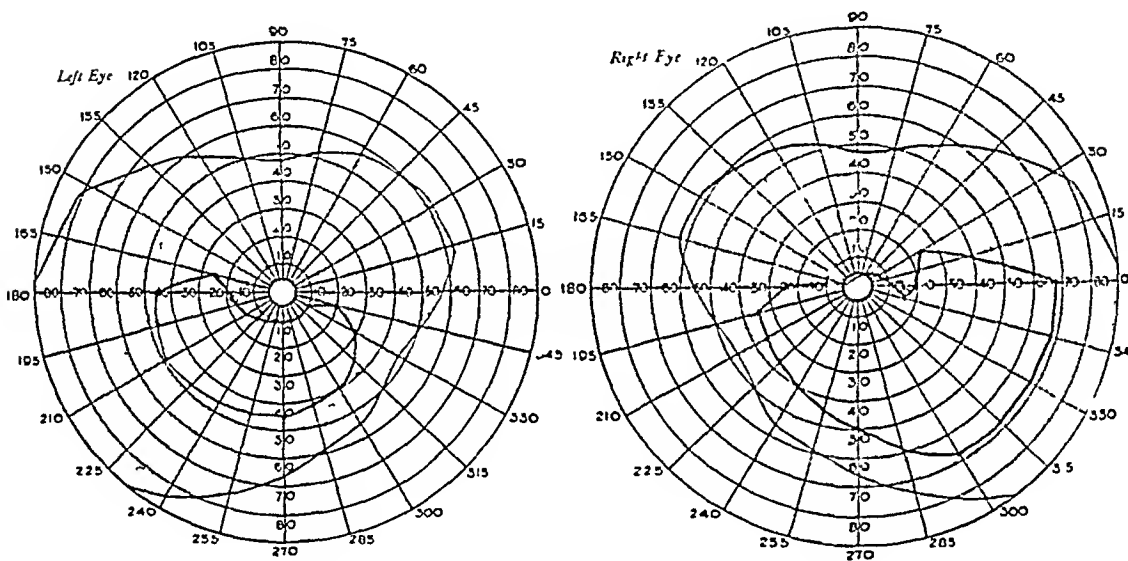


Fig 2—Visual fields at time of operation (1946)

adhesions in the angle of the left eye. The visual fields (fig 2) showed extensive loss in the superior portion in each eye.

On Jan 18, 1946, the patient was admitted to the New York Hospital for study. His medical history revealed that syphilis had been suspected in 1925 and an intensive course of arsenobismuth therapy given, apparently without definite proof of the disease. Frequent subsequent serologic tests had given negative reactions, and two examinations of the spinal fluid had revealed nothing abnormal. He had passed a small bladder stone in 1941. His medical history was otherwise essentially not remarkable. Physical examination (except for his eyes) showed only slight cardiac enlargement and a blood pressure of 155 systolic and 82 diastolic. The blood cells and urine were normal, and serologic tests for syphilis gave negative reactions. The electrocardiogram and the electroencephalogram were normal. Roentgenograms of the skull were normal and failed to disclose any unusual sclerosis of the carotid arteries (fig 3). Lumbar puncture revealed that the spinal fluid was under normal pressure, with a normal protein content, a normal colloidal gold curve and a negative Wassermann reaction. Visual fields

as determined repeatedly were similar to those in figure 2. The water-drinking and homatropine provocative tests for glaucoma gave negative results. There seemed to be sufficient evidence of a lesion at the base of the brain to warrant exploration.

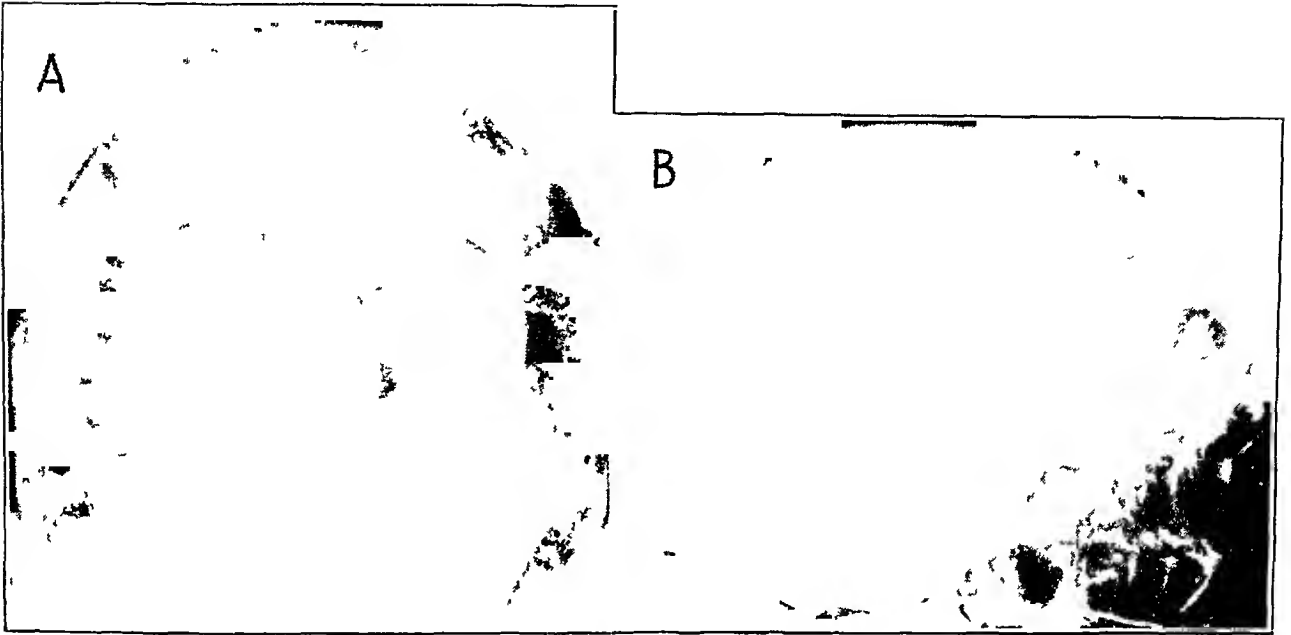


Fig 3—Roentgenograms of the skull

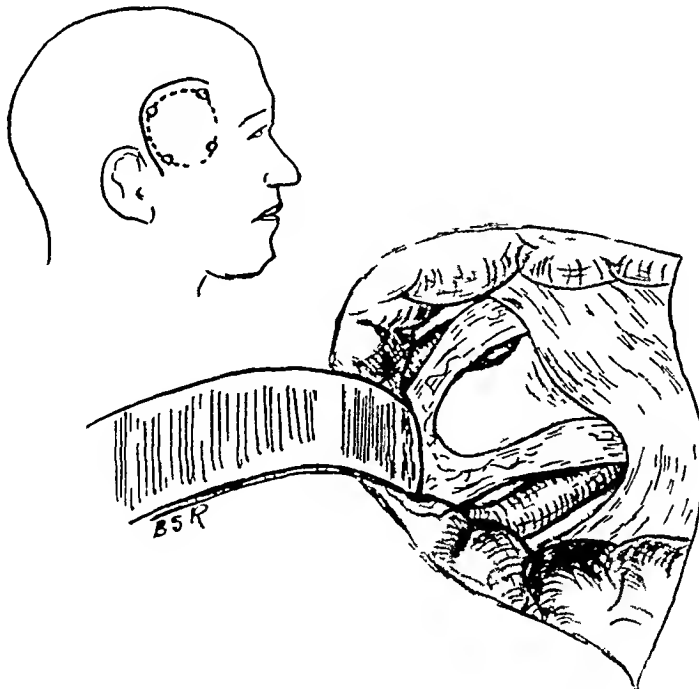


Fig 4—Sketch of exposure at operation

Accordingly, on Jan 28, 1946, one of us (B R) exposed the region of the chiasm and both optic nerves. This was done through an incision in the skin just behind the hair line and a frontotemporal bone flap. The frontal lobe was easily retracted, and the subarachnoid space was observed to be wide and free from

that the type of deformity depends on the stage of embryonic development in which it occurs. This idea was linked to heredity by Meckel<sup>5</sup> in 1812. In 1882 His<sup>6</sup> expressed the belief that all malformations are related to a germinal defect. This opinion was amplified by Wilder<sup>7</sup> in 1908 and was further upheld by Fischel's<sup>8</sup> experiments (1921).

No attempt is made to review the older literature on cyclopia, as this has been done by Hill<sup>9</sup> (1920 and 1921), Chapman<sup>10</sup> (1936) and Wilbur<sup>11</sup> (1939). It is common to find certain other abnormalities associated with cyclopia, such as deformity of the palate, coloboma and other defects of the eyes, brain and skull, or a proboscis, usually situated above the central, cyclopean, eye. Less frequently, cleft palate and cleft lip are seen, and rarely polydactyly is present. Lateral proboscis is also frequently associated with cleft palate and coloboma of the eyelids.

It is of considerable interest that atypical monozygotic twinning sometimes occurs in cases of cyclopia and of lateral proboscis associated with coloboma. In relation to our case, the importance of twinning lies in the fact that incomplete separation of twins derived from a single ovum results in the formation of "monsters" of various types. When the separation is nearly complete, the result is the well known "Siamese twins." With further separation there may be duplication of only certain parts, such as the head or the facial features.

It is commonly accepted that cyclopean eye is one of the results of incomplete separation. Lateral proboscis has not previously been considered a result of atypical monozygotic twinning.

Modern studies include histologic details and results of experimental work. The influence of embryonic environment on the germ potentialities is also stressed. Our case represents a combination of defects of the eye and nose and closely related malformations of the face, which we shall consider in the light of present knowledge and attempt to formulate an interpretation.

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5 Meckel, J. F. *Handbuch der pathologischen Anatomie*, Leipzig, C. H. Reclam, 1812-1816.

6 His, W. *Anatomie menschlicher Embryonen. II. Gestalt- und Grossenentwicklung bis zum Schluss des 2 Monats*, Leipzig, F. C. W. Vogel, 1882.

7 Wilder, H. H. *The Morphology of Cosmobia. Speculations Concerning the Significance of Certain Types of Monsters*, *Am. J. Anat.* **8**: 355, 1908.

8 Fischel, A. *Ueber die normale und abnorme Entwicklung des Auges*, *Arch. f. Entwicklungsmech. d. Organ.* **49**: 383, 1921.

9 Hill, E. *Cyclopia. Its Bearing upon Certain Problems of Teratogenesis and of Normal Embryology with a Description of a Cyclocephalic Monster*, *Arch. Ophth.* **49**: 597, 1920, **50**: 52, 1921.

10 Chapman, K. H. *Human Cyclopia*, *Arch. Ophth.* **16**: 40 (July) 1936.

11 Wilbur, I. E. *Human Cyclopia with Associated Ocular Anomalies. A Case Report and Embryological Interpretations*, *Am. J. Ophth.* **22**: 1120, 1939.

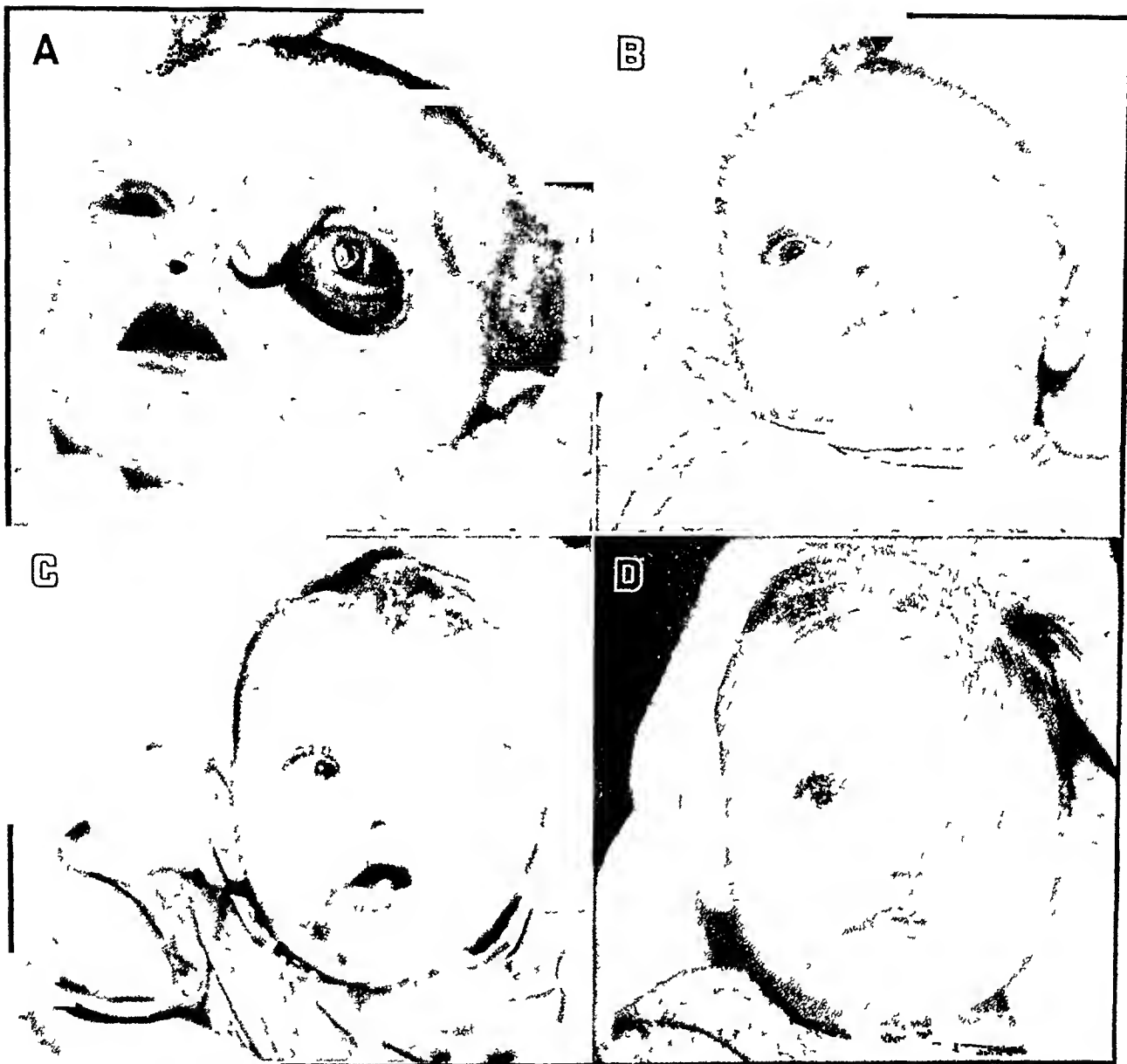


Fig 1—Kodachromes *A*, 10 day infant with lateral proboscis, cyclopean eye and double corneas with two irises and two pupils *B*, appearance seven months after removal of the proboscis, amputation of the anterior half of the globe and plastic closure of the socket *C*, infant when 13 months old, showing flattening of the left side of the face and the forehead The right side is normal, with normal eye and naris The brown pigmentation on the skin is from eating chocolate *D*, infant when 2 years old, showing flattening and underdevelopment of the left side of the face with the anterior portion of the cranium more pronounced than the rest of the skull There is probable agenesis of the left cerebral hemisphere, with weakness of the right hand and foot In mental status the child was at the moron level, with good behavior adjustment



In a thorough search of the available literature, we have found no exact duplicate of the malformations present in our case. Therefore, we shall attempt here to discover its place in the graded types of malformations of the eye and nose delineated by Forster,<sup>12</sup> Sommerring,<sup>3</sup> Wilder,<sup>7</sup> Rating<sup>13</sup> and Redenz<sup>14</sup>

#### REPORT OF CASE

*History*—A 10 day old male infant was admitted to the service of Dr Adolph De Sanctis at the New York Post-Graduate Medical School and Hospital on Sept 30, 1940. He was the second child of normal parents, a full term 9 month infant, weighing 7 pounds 8 ounces (3,400 Gm) at birth. Labor was normal. The child was well developed and of normal size, the abnormalities were confined to the head. The family history revealed nothing of significance except that the maternal grandfather was one of identical twins.

The left eye was greatly enlarged and proptosed (fig 1 A), the conjunctiva was intensely chemotic and bulging, and a double cornea with two irises and two pupils was plainly visible. The nasal cornea showed necrosis, and the anterior chamber was cloudy, with hypopyon. The temporal cornea was clear, as was the anterior chamber beneath. The iris was a clear blue. Attached to the superior nasal part of the orbit, and freely movable, was a firm tubular structure 40 mm long and about 10 mm in diameter. An opening 2 mm in diameter, through which mucus could be expressed, was present at the tip of this tubular structure. The right half of the nose and the right eye presented no abnormalities. Just above the upper lip in the midline there was a small protruding mass, which measured 0.5 by 0.5 cm and was red and soft. On each side of the hard palate anteriorly there was a whitened area, about 1 by ½ inch (2.5 by 1.3 cm) and not raised. A roentgenogram of the mouth showed developmental asymmetry and cleft hard palate. The skull was elongated in its vertical diameter, with wide spacing of the orbits and broadening of the nares, convolutional markings were accentuated, the parieto-occipital area and the sella turcica were about 20 per cent undersize.

The diagnosis was that of relatively small, underdeveloped left orbit and bones of the left side of the face, complete blockage of the left nasal region and underdeveloped sinuses.

In view of the presence of panophthalmitis, and in the absence of complete knowledge of what defects there might be in the bony structures behind the proptosed globe, removal of the anterior half of the globe with evisceration of the posterior contents of the eyeball seemed the procedure of choice. The idea of obtaining the eye in toto was reluctantly abandoned because of its purulent condition and the attendant hazard of death from meningitis.

On Oct 3, 1940, with the patient under ether anesthesia induced by the drop method, the conjunctiva was cut around the limbus and freely undermined. The sclera was cut in a circular fashion about 6 mm from the limbus, and the anterior

12 Forster, A. J. T. Die Missbildung des Menschen systematisch dargestellt, Jena, F. Mauke, 1861.

13 Rating, B. Ueber eine ungewöhnliche Gesichtsmissbildung bei Anencephalie, Virchows Arch f. path. Anat. **288** 223, 1933.

14 Redenz, E. Ueber Erscheinungsformen und Genese der Arrhinenzephalie und Zyklopie und die Bedeutung gekoppelter Missbildungen, Ztschr. f. Geburtsh. u. Gynak. **114** 185, 1937.



segment of the eyeball was removed. The posterior scleral cavity was eviscerated, apparently, only one cavity was present. The scleral sac was packed with iodoform gauze and the conjunctiva closed with interrupted silk sutures, leaving a small central opening for removal of the packing. The infant had an uneventful post-operative recovery, took his formula well and began to gain weight.

On December 12, with the infant under ether anesthesia, induced by the open drop method, the proboscis, in the nasal part of the left orbit, was removed and a plastic orbital reconstruction performed. The anomalous proboscis was raised, and on the nasal side a rectangular skin flap was fashioned. The proboscis was dissected down to its dense fibrous attachment to the superior nasal part of the

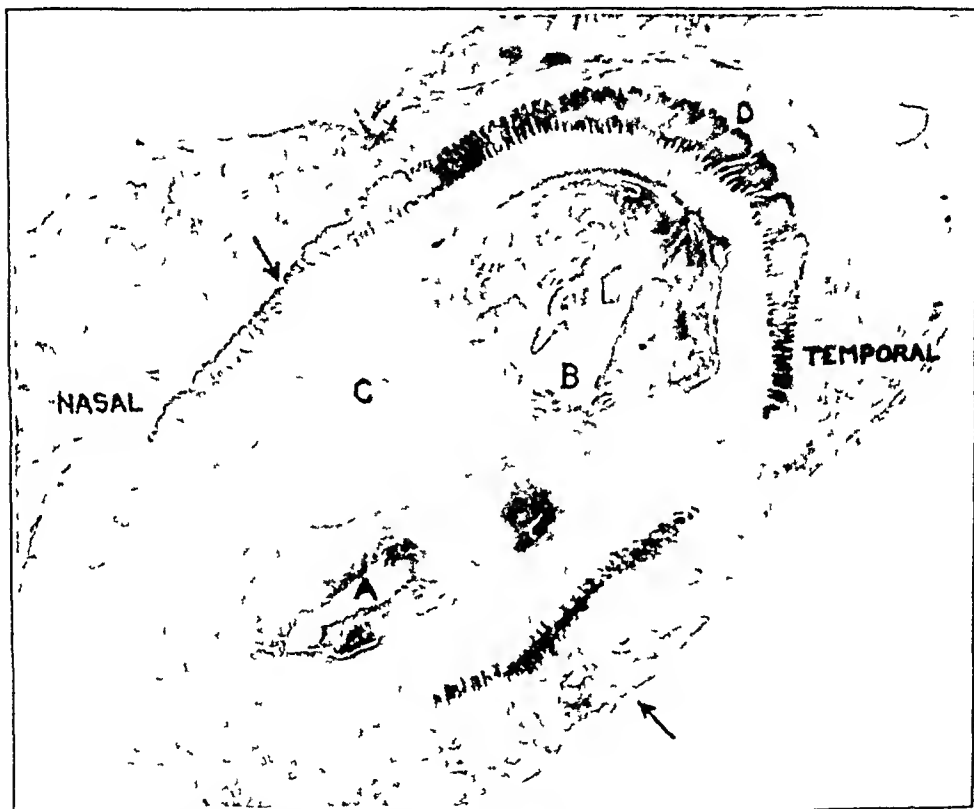


Fig 2—Microscopic section (oblique) from a cyclopean eye through the base of the cornea, measuring 16 by 8 mm. *A* and *B*, anterior chambers of the double cyclopean eye, with ulceration of the corneas. *C*, ciliary muscle (arrow marks the sclera). Purulent exudate is present in both *A* and *B*. *D*, corneal epithelium.

left orbit and was cut at its attachment. The short, tense left upper lid was cut parallel to the orbital ridge and split into two layers. The left lower lid was also split along the intermarginal white line into its two layers. The conjunctival layer of the freed upper lid and that of the lower lid were sutured together with chromic surgical gut. The cilia were excised from the outer layers, and the skin of the upper lid and that of the lower lid were sutured together with interrupted silk sutures. The rectangular pedicle skin flap, previously fashioned, was then trimmed and the defect in the upper lid closed with this skin flap. Postoperative healing was uneventful (fig 1 *B*).

## PATHOLOGIC EXAMINATION

**Eye—Gross Observations** The specimen from the eye was an oval disk of semitransparent fibrous tissue, 18 by 15 mm in area and 2 mm thick. The slightly convex surface showed wrinkled, white and gray tissue with two lateral, similarly depressed areas, a few millimeters in diameter, situated in the center of each half; these areas were partly necrotic and mottled with brown pigment. The under surface was lined with a ragged brown layer, suggesting iris, and flecks of pus clung to the irregular tabs.

**Microscopic Observations** The specimen was embedded *in toto* in paraffin, and serial sections of the whole specimen were cut approximately in a frontal plane.

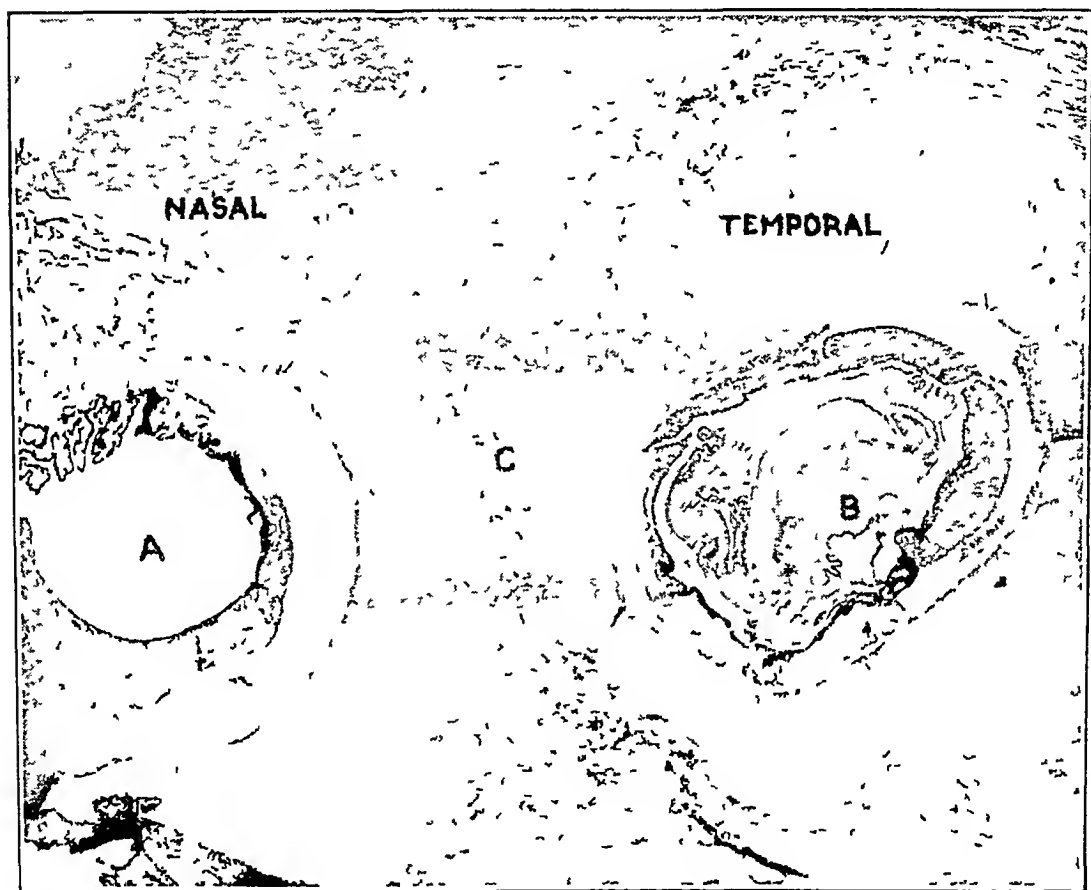


Fig 3—Microscopic section (oblique) through the ciliary region of the double cyclopean eye. *A*, one anterior chamber with iris and ciliary processes, *B*, anterior chamber, iris and prolapsed lens with colonies of bacteria, *C*, ciliary muscle and vessels of the anterior portion of the sclera.

and stained with hematoxylin and eosin. Interpretation was difficult because of the ulceration and the presence of purulent exudate and colonies of *Staphylococcus aureus*. The first sections showed two ulcerating areas in the cornea, with loss of tissue and two separate openings, the spaces extending completely through the cornea (fig 2, *A* and *B*). A transversely elongated rim of stratified squamous epithelium with blunted rete pegs enclosed both spaces in a continuous layer, but they were separated by sclera (*C*) and ciliary muscle. Each opening (fig 3, *A* and *B*) showed a pupil with an enclosing ring of iris and ciliary processes. The separate pupils were without pupillary membranes (fig 5, ciliary epithelium in fig 3, *B*).

*Nose*—Gross Observations The proboscis, on the left side, measured 4 cm in length and 12 mm in diameter at the tip and narrowed to 9 mm at the root. It was covered with skin except at the line of excision. A canal, approximately 3 mm in diameter, ran the entire length of the proboscis.

Microscopic Observations Sections were made through the nostril, the mid-portion and the root of the nasal proboscis. Each area was lined with its normal mucous membrane. The nostrils were lined with squamous epithelium, hair and sebaceous glands (fig 6). Normal schneiderian membrane, including mucous glands, covered the turbinate processes (fig 7), with a thinner layer in the frontal

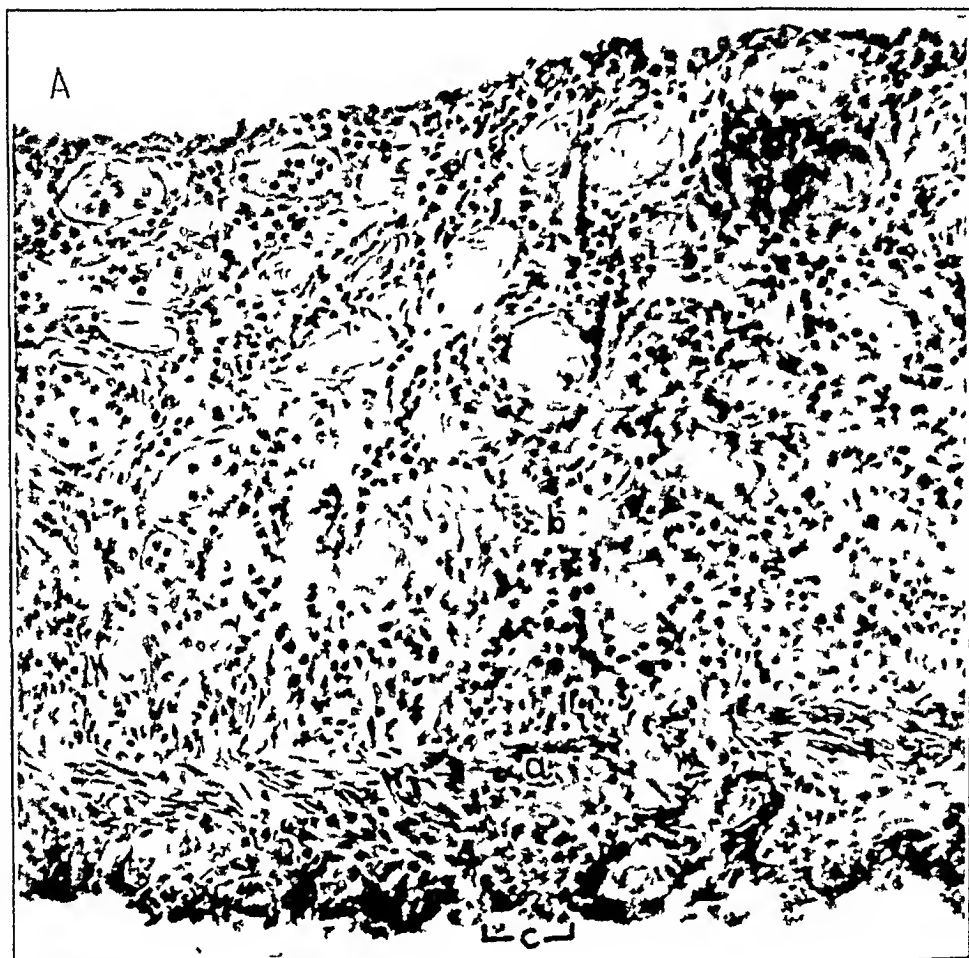


Fig 4—Microscopic section of the iris. *A* and *B* (from *A* and *B*, respectively, of figure 3) *a*, sphincter muscle of the iris, *b*, stroma, and *c*, pigment epithelium.

region of attachment (fig 8). The plaques of cartilage were of fetal type but were found in the nares and the turbinate bone, and ossification was present at the root of the proboscis.

*Diagnosis*—The diagnosis was cyclopean eye, double, and lateral proboscis, each on the left side.

*Course*—During the succeeding three and one-half years the child was kept under observation and readmitted to the hospital at intervals for further study. At 7 months of age flattening of the left side of the face and of the forehead

was visible. The head was definitely misshapen, the entire right side being larger than the left (fig 1 C). Roentgenograms of the skull and sinuses showed a small, underdeveloped left orbit and underdevelopment of the bones of the left side of face, complete blockage of the left nasal region and underdeveloped sinuses.

At 2 years of age (fig 1 D) the flattening and underdevelopment of the left side of the face and the anterior portion of the cranium were more pronounced. Further roentgenographic study showed an evident congenital anomaly with



Figure 4 B

developmental asymmetry, there being a relatively small orbit on the left side, with bony condensation and hyperostosis of the left ethmoidal region and naris and wide spacing between the orbital margins. The antrums were poorly developed and the left naris was occluded. The hard palate was cleft and conically arched toward the left orbit, and the upper lip showed a streaked dimpling to the left of the columella. Neurologic examination showed reduction of the deep reflexes, weakness of the right hand and foot and probably agenesis of the left cerebral

hemisphere. Examination of the mental status indicated that intelligence was at the moron level, with good behavior adjustment.

At 3 years of age the abnormalities noted were more pronounced, and definite weakness of the right side was evident. The boy could now walk and play with his brother and say a few words, but his mental status was definitely on the moron level.



Fig 5—Microscopic section from *B* in figure 3, showing lens (*a*) and retinal epithelium near the ora serrata (*b*)

A report of a social worker in 1943 stated that the child had become obstinate and occasionally had attacks of a convulsive nature. He was placed in a state institution at the age of 4 years because his mother was unable to care for him adequately and because it was believed that his presence in the home would have a bad effect on the other child, who was normal. Report of an examination made in May 1945 follows:

"K is a restless, overactive, mischievous boy. His head and face are asymmetric. The left nostril is absent, the right is apparently normal. The left eyebrow now extends along the left side of the nose. The left eye is absent and the orbit is covered with skin, there is a small sinus at the inner angle, through which lacrimation takes place. There is some loss of use of the right hand, which he holds in a

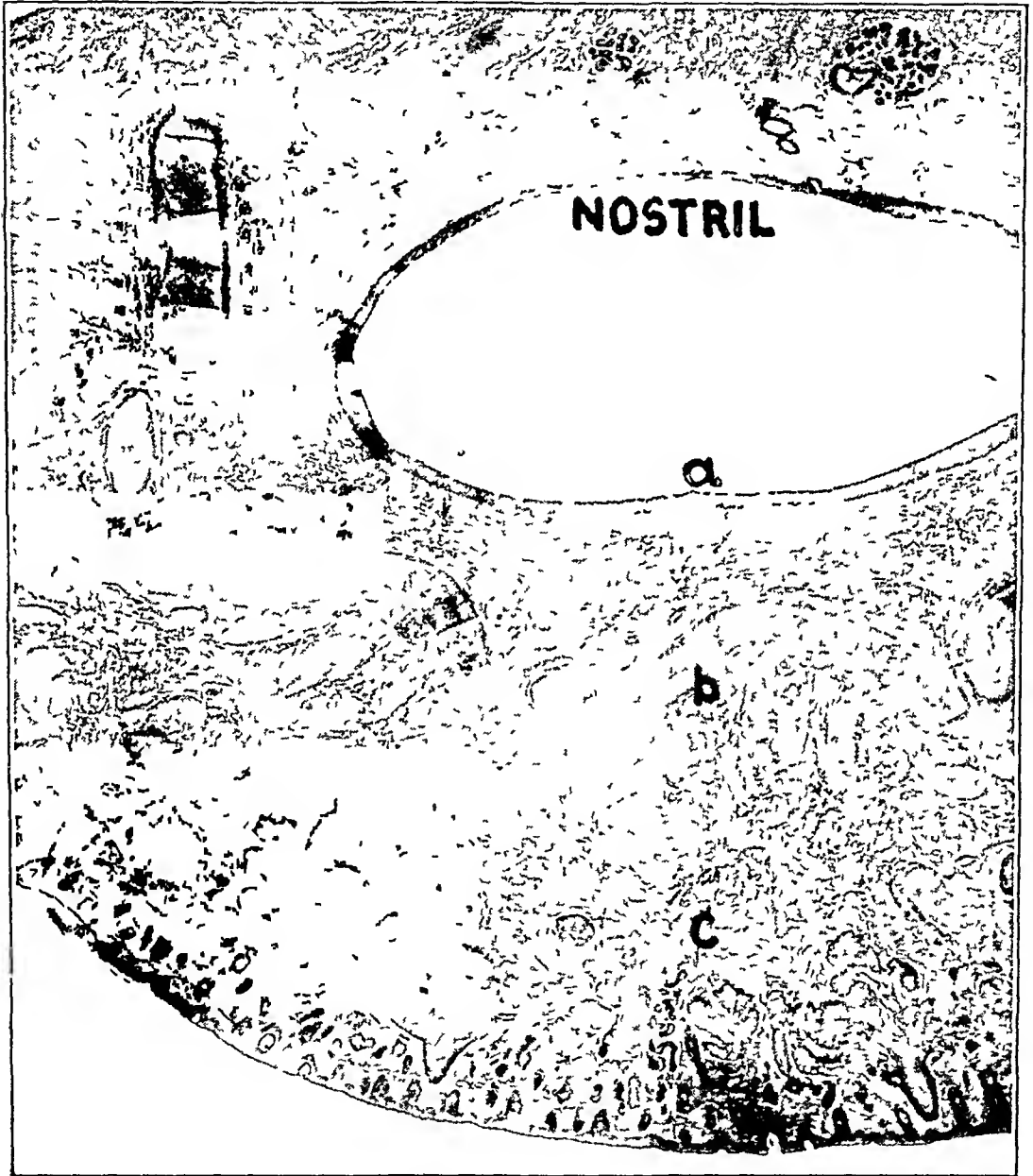


Fig 6—Proboscis. Microscopic section of the nostril, showing the lumen. Present are the mucosa (a), cartilage (b) and skin (c), which is normal.

flexed position. His gait is defective. Reflexes are exaggerated on the right side. He can understand simple verbal material and can say a few very simple words indistinctly. His reaction time is rapid. Memory is poor. His basal mental age is 12 months, and the upper limit, 3 years, with one test passed at this level. He failed in all four tests. His intelligence quotient, of 41 (Kuhlman), was determined on the basis of his actual age. He plays fairly well with the other boys in his ward.

double cleft lip and cleft palate There were three orbital cavities in the skull (fig 9)

3 Bimar's<sup>15</sup> case (1888), an extraordinary one also, was that of a woman who lived to be 52 The depression in the skin above and between the two noses marked an orbital cavity between the two orbits containing the right and the left eye, but the third orbit contained no eye This peasant woman led a normal life and was self supporting The author suggested incomplete twinning as the causal factor (fig 9)

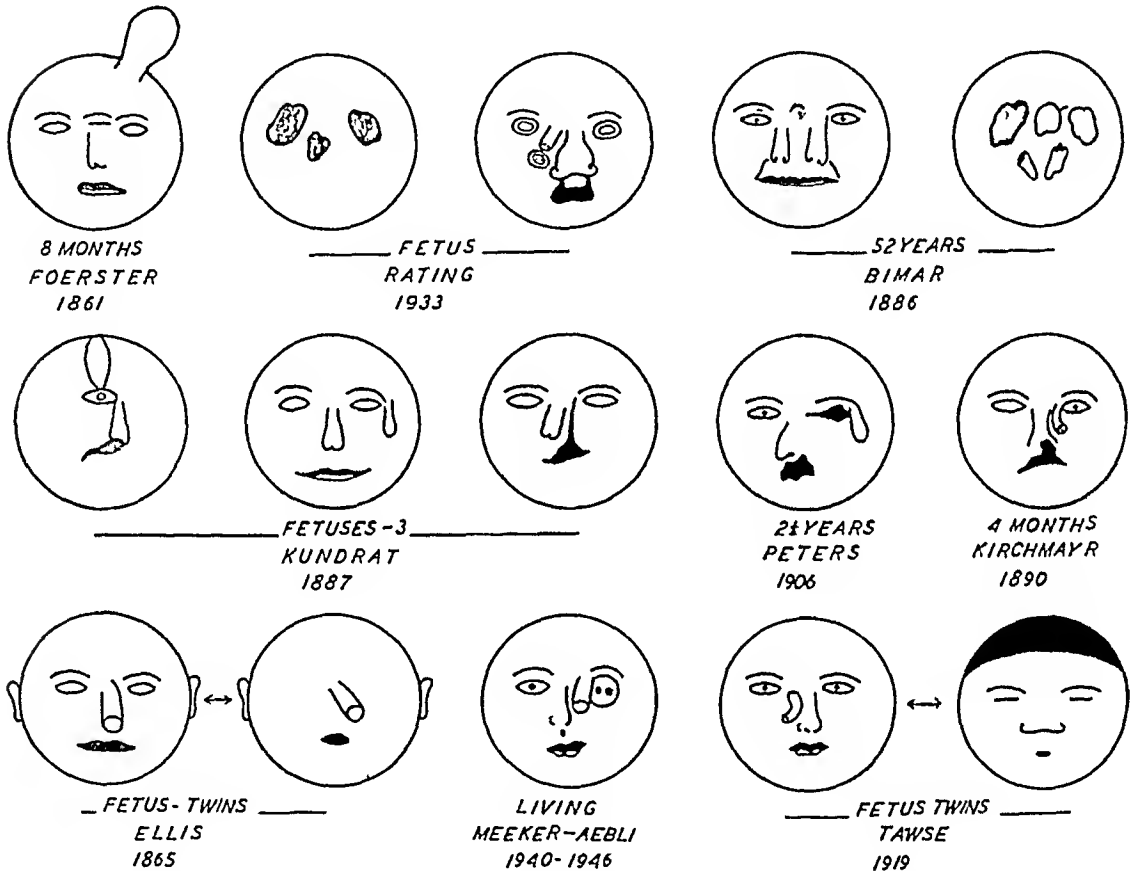


Fig 9—Chart illustrating the cases cited in the text to indicate the relationship of lateral proboscis, cyclopean eye, cleft palate and atypical monozygotic twinning Isolated, rarer, cases of persons with three eyes or three eye "sockets" are also known

4 Lehmann-Nitsche's<sup>16</sup> case (1901) was that of a youth aged 18 and was similar to Bimar's case This youth had sufficient intelligence to earn his living as a farmer but was constantly in trouble with the police

<sup>15</sup> Bimar Note sur un monstre pseudocéphalien, *Gaz hebdomadaire de médecine et de chirurgie* 8 349 and 385, 1886

<sup>16</sup> Lehmann-Nitsche, R Ein seltener Fall von angeborener medianer Spaltung der oberen Gesichtshälfte, *Virchows Arch f path Anat* 163 126, 1901

5 Kirchmayr's<sup>17</sup> case (1906), that of a girl 4 months old, showed the association of lateral proboscis and coloboma of the lids, cleft lip and cleft palate (fig 9)

6 Selenkoff's<sup>18</sup> case, that of a man aged 54, is interpolated here to illustrate the lateral proboscis and the upper lid and eyebrow continuing along the nose, the latter coming under the heading of Gesell's atypical twinning processes. Our patient now shows the same growth of the eyebrow

#### COMMENT

Our case may be considered from the standpoint of the four associated malformations, namely, cyclopean eye, lateral proboscis, cleft palate and cleft lip

Cyclopean eye, occurring in association with cleft palate, coloboma of the lids and in monozygotic twinning, and rarely with polydactyly, has been reported by Kundrat,<sup>19</sup> Rating<sup>13</sup> and van Duyse<sup>20</sup>. Arey,<sup>21</sup> Fuchs,<sup>22</sup> Duke-Elder,<sup>23</sup> Pires de Lima<sup>24</sup> and Gesell and Blake<sup>25</sup> were convinced that the cyclopean eye is an expression of monozygotic twinning

Lateral proboscis in combination with cleft palate and coloboma of the ocular tunics and lids and in monozygotic twinning has been reported by Kundrat,<sup>19</sup> Peters,<sup>26</sup> Tendlau,<sup>27</sup> van Duyse<sup>28</sup> and Tawse.<sup>29</sup> Lateral proboscis and cleft palate, occurring singly or in combination, are accepted as hereditary (Arey<sup>21</sup> and Thoma<sup>30</sup>)

17 Kirchmayr, L. Ein Beitrag zu den Gesichtsmisbildung, Deutsche Ztschr f Chir **81** 71, 1906

18 Selenkoff, A, cited by Henke, F, and Lubarsch, O. Handbuch der speziellen pathologischen Anatomie und Histologie, Berlin, Julius Springer, 1921-1938, vol 3, pt 1, p 56, fig 52

19 Kundrat. Ueber Nasen- und Gesichtsspalten, Munchen med Wchnschr **34** 90, 1887

20 van Duyse. Pathogénie de la cyclopie, Arch d'opht **18** 481, 581 and 623, 1898

21 Arey, L B. Developmental Anatomy, ed 4, Philadelphia, W B Saunders Company, 1940

22 Fuchs, E. Text-Book of Ophthalmology, translated by A Duane, ed 7, Philadelphia, J B Lippincott Company, 1923

23 Duke-Elder, W S. Text-Book of Ophthalmology, St Louis, C V Mosby Company, 1938, vol 2, p 1244

24 Pires de Lima, J A. Monstros ciclocefalíanos, Folia anat univ comb (art 14) **15** 1, 1940

25 Gesell, A, and Blake, E M. Twinning and Ocular Pathology, with a Report of Bilateral Macular Coloboma in Monozygotic Twins, Arch Ophth **15** 1050 (June) 1936

26 Peters, A. Ueber die bei Missbildungen des Gesichtes vorkommende Russelbildung, Ber u d Versamml d ophth Gesellsch **36** 163, 1911



Cleft palate has frequently occurred in conjunction with cyclopean eye and lateral proboscis, in identical twins (Kundrat,<sup>19</sup> Heimonen,<sup>31</sup> Tawse,<sup>29</sup> and Ellis<sup>32</sup> and with polydactyly (Birkenfeld<sup>33</sup>)

The hereditary factor is also important in cleft lip, for Schroder<sup>34</sup> found a hereditary factor in 42.7 per cent of cases, in 75 per cent of which it was recessive and in 25 per cent dominant. Additional evidence of hereditary influence was supplied by Klopstock,<sup>35</sup> van Duyse,<sup>20</sup> Schroder,<sup>34</sup> Haymann,<sup>36</sup> Thoma,<sup>30</sup> Saunders<sup>37</sup> and Rating,<sup>13</sup> who suggested that inheritance of cleft lip followed the mendelian law, and Redenz<sup>14</sup> expressed the same opinion about cyclopean eye and the central proboscis.

It is of particular interest that these anomalies are often associated with monozygotic twinning. The suggestion has been made that partial fusion of twins results in a person with duplication of features. A better explanation, however, is that there is incomplete separation of monozygotic twins, as suggested by Ellis<sup>32</sup> and Tawse<sup>29</sup> (fig 9). This explanation does not weaken the theory of the influence of heredity but, rather, strengthens it, for monozygotic twinning is itself probably under hereditary influences (Newman,<sup>38</sup> Gesell and Blake,<sup>25</sup> Thoma<sup>30</sup>). Two remarkable examples of hereditary influence in twinning (Newman<sup>38</sup>) are afforded by the Picard and Rubin families, in which the parents on both sides were uniovular twins and uniovular twins were born into both families.

27 Tendlau, A. Ein Fall von Proboscis lateralis, *Arch f Ophth* 95 135, 1918

28 van Duyse, G. M. Proboscide laterale et colobome oculaire atypique avec lenticone posterieur, *Arch d'ophth* 36 463 and 555, 1919

29 Tawse, H. B. Supernumerary Nostril and Cavity, *Proc Roy Soc Med (Sect Laryng)* 13 28, 1919-1920

30 Thoma, K. H. Oral Pathology, St. Louis, C. V. Mosby Company, 1941

31 Heimonen, O. Ueber die Refraktion bei eineigenen Zwillingen, speziell in Hinsicht der asymmetrischen Fälle, *Acta ophth* 2 35, 1924

32 Ellis, R. On a Rare Form of Twin Monstrosity, *Tr Obst Soc London* 7 160, 1865

33 Birkenfeld, W. Ueber die Erbllichkeit der Lippenspalte und Gaumenspalte, *Arch f klin Chir* 141 729, 1926

34 Schroder, C. H. Untersuchungen über die Vererbung der Hasenscharte und Gaumenspalte mit besonderer Berücksichtigung des Erbgangs, *Arch f klin Chir* 182 299, 1935

35 Klopstock, A. Familiäres Vorkommen von Cyklopie und Arrhinencephalie, *Monatschr f Geburtsh u Gynak* 56 59, 1921

36 Haymann, A. T. Amniogene und erbliche Hasenscharten, *Inaug Dissert (Leipzig)*, Berlin, L. Schumacher, 1903

37 Saunders, J. De erfelijkheid van hazelip en gespleten verhemelte, *Tijdschr v tandheelk* 41 439, 1934

38 Newman, H. H. Multiple Human Births, American Association for the Advancement of Science Series, New York, Doubleday, Doran & Company, Inc., 1940

Consideration of the present case thus shows that in each of the four associated anomalies heredity is known to play an important role and that their association with atypical monozygotic twinning is more than an accidental occurrence

On the basis of this discussion, the suggestion is made, therefore, that the anomalies in this case are the result of incomplete separation of monozygotic twins and that hereditary influences are important factors in their development .

#### SUMMARY

A case is reported in which cyclopean eye, lateral proboscis, cleft palate and cleft lip are associated. There is no case in the available literature in which these anomalies have been associated in the manner described, and ours is the only case of cyclopean eye in which the child has lived to the age of  $5\frac{1}{2}$  years.

Comparison of this case with the cases previously reported strongly suggests that the defects are the result of incomplete separation of monozygotic twins. Hereditary influences are of importance not only in the occurrence of the individual anomalies but in the formation of the twins on which their development depends.

30 East Fortieth Street

## SPECIFIC TREATMENT OF OCULAR BURNS DUE TO LEWISITE ( $\beta$ -CHLOROVINYLDICHLOROARSINE)

IRVING H LEOPOLD, M D  
AND  
FRANCIS HEED ADLER, M D  
PHILADELPHIA

RECENTLY Peters,<sup>1</sup> in England, and Waters and Stock,<sup>2</sup> in the United States, have presented information concerning an effective antiarsenical agent, BAL (2, 3-dimercaptopropanol), which was discovered and developed during the war years. It has been shown not only to be an effective therapeutic agent against arsenical war agents but also to be of value in the treatment of the various types of arsenical poisonings encountered in civilian practice.

It is the purpose of this review to give a brief summary of the development of BAL for ocular therapeutic use.

### PHYSICAL AND CHEMICAL PROPERTIES

Among the early forms of BAL tested for therapeutic effect in the eye in this country were NDR 133-J, NDR 133-N, NDR 133-Q-Z, NDR 133-5, NDR 133-11 and NDR 133-12.<sup>3</sup> These were all 2, 3-dimercaptopropanol of varying degrees of purity and prepared by different modifications in the chemical process. Composites of later preparations of BAL were NDR 133-26 and NDR 133-27, and one composite lot, NDR 133-28, is now known as American Reference Standard (ARS) BAL. This compound must meet definite physical and chemical requirements,<sup>4</sup> with respect to such factors as  $pH$ , color, refractive index, bromine content, thiosulfur content and heat stability. In addition, its toxicity must not exceed a certain minimum, and it must possess a standard therapeutic efficiency.<sup>4</sup>

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1 Peters, R A, Stocken, L A, and Thompson, R H S. *Nature*, London **156** 616 (Nov 24) 1945.

2 Waters, L L, and Stock, C. *Science* **102**, 601 (Dec 14) 1945.

3 NDR stands for National Defense Research Committee.

4 Calvery, H O, Braun, H A, Draize, J H, Woodward, G, Vos, B, Fassett, D, Fitz Hugh, O, and Whiteman, G. Personal communication to the authors, April 1943.

American Reference Standard BAL is a clear, colorless fluid with a pungent and disagreeable odor. It is soluble in vegetable oils, alcohols and water up to 7 per cent and is freely soluble in various organic solvents. The most used solvents for ocular use have been ethylene and propylene glycol, ethyl phthalate, water and "cellosolve" (ethylene glycol monoethyl ether).

BAL is readily oxidized. It is oxidized more rapidly in water than in ethylene glycol and more rapidly in dilute than in concentrated solution.<sup>5</sup> It is readily oxidized by minute quantities of iron or copper.<sup>6</sup>

The American Reference Standard BAL produces a clear 5 per cent aqueous solution.<sup>7</sup> However, the aqueous solution of ARS BAL, like others, shows cloudiness and even droplet separation on standing, these droplets are probably polymers of BAL.<sup>8</sup>

#### TOLERANCE OF EYES TO BAL

All the forms of BAL listed in the preceding section have been tested for ocular tolerance in rabbits.<sup>9</sup> The later preparations of BAL have also been tested in monkeys<sup>9b</sup> (September communication) and in human subjects.<sup>10</sup> Concentrations as low as 5 per cent will produce conjunctival injection, blepharospasm and lacrimation. The symptoms may be severe enough to render a man a casualty for as long as fifteen minutes, although the severest blepharospasm usually lasts only two to five minutes.<sup>11</sup> A few drops of 5 per cent aqueous solution of BAL or 0.1 cc. of an ointment containing BAL in 5 per cent concentration may cause a conjunctival injection lasting an hour. Visual function probably will not be greatly influenced longer than fifteen minutes after application. By increasing the concentration from 5 to 10 per cent, one increases the amount and degree of conjunctival irritation but fails to produce any permanent corneal damage in rabbit eyes.<sup>9</sup>

Concentration of BAL above 20 per cent may produce irreparable corneal damage, the eyes may eventually heal but with scar formation. If concentrations higher than 25 to 30 per cent are used, many of the eyes will fail to heal sufficiently to leave function.

5 Adler, F. H., Leopold, I. H., Steele, W. H., and Crandall, A. S. Personal communication to the authors, January 1943.

6 Barron, G. Personal communication to the authors, June 1943.

7 (a) Adler, F. H., Leopold, I. H., and Steele, W. H. Personal communication to the authors, June 1942. (b) Calvery and others.<sup>4</sup>

8 Brubaker, M. M. Personal communication to the authors, August 1942.

9 (a) Adler, F. H., Leopold, I. H., and Crandall, A. S. Personal communication to the authors, April and July 1942. (b) Hughes, W. Personal communication to the authors, June and September 1942. (c) Calvery and others.<sup>4</sup>

10 Adler, F. H., Leopold, I. H., Steele, W. H., and Crandall, A. S. Personal communication to the authors, December 1942. Hughes<sup>9b</sup>

11 (a) Barr, J., and Sulzberger, M. Personal communication to the authors, July 1943. (b) Lazier, W. A., and Salzberg, P. L. Personal communication to the authors, July 1943.

These results are the same regardless of whether the material is administered in the form of drops or as an irrigant, when a total of 2 cc is used<sup>12</sup> Continuous use of any BAL was found to be harmful to both the normal eye and to an eye burned with lewisite ( $\beta$ -chloro-vinyl-dichloroarsine) If BAL, for example, is used twice daily for several days on lewisite-burned eyes, the eyes will remain inflamed until the BAL therapy is stopped and will then clear in twenty-four to thirty-six hours<sup>9a</sup> It has been reported that the reactions produced by concentrations of BAL over 5 per cent in eyes previously exposed to lewisite are severer than those produced by BAL on the normal cornea and that this indicates that lewisite lowers the tolerance of the cornea for BAL This action is probably not specific, since to an eye inflamed by any irritant other than lewisite BAL is more irritating than, to a normal eye

#### SENSITIVITY OF OCULAR TISSUES TO BAL

Attempts to induce hypersensitivity to BAL in eyes of rabbits by repeated applications have failed in normal eyes, as well as in eyes previously exposed to lewisite and treated with BAL<sup>13</sup> This does not necessarily mean that human eyes may not become sensitive, for rabbits are notoriously poor animals on which to perform experiments on acquired sensitivity Sulzberger has demonstrated a type of hypersensitivity of human skin to BAL<sup>11a</sup>

#### THERAPEUTIC EFFECTIVENESS OF BAL

After the fundamental investigations of Stocken and Thompson<sup>14</sup> that led to the use of BAL for lesions of the skin produced by lewisite, Mann and her associates<sup>15</sup> were the first to evaluate BAL as a therapeutic agent for ocular lesions In view of the excellent results on ocular injuries due to lewisite obtained by many British workers, BAL was tried in the United States<sup>9a</sup> Work done with previously recommended therapeutic agents for lesions due to lewisite, such as hydrogen peroxide and potassium permanganate, conclusively proved the superiority of BAL<sup>16</sup> After the efficacy of this compound had been demonstrated, the following points had to be considered

12 Adler, F H , Leopold, I H , Steele, W H , and Crandall, A S Personal communication to the authors, February 1943

13 Adler, F H , Leopold, I H , Steele, W H , and Crandall, A S Personal communication to the authors, November 1942

14 Stocken, L A , and Thompson, R H S Personal communication to the authors, 1941 and 1942

15 (a) Mann, I, and Pirie, A Personal communication to the authors, 1941 and 1942 (b) Clarke, A J Personal communication to the authors, 1941 and 1942 (c) Robson, J M, and Scott, G I Personal communication to the authors, 1941 and 1942

16 Mann, I, and Pirie, A Personal communication to the authors, 1941 and 1942 Adler, F H , Leopold, I H , and Crandall, A S Personal communication to the authors, April and May 1942

*Time of Initial Application*—BAL was found to give excellent results when used within five minutes after contamination of the eyes with lewisite<sup>17</sup> The majority of eyes treated within five minutes can be expected to show at the most only slight residual corneal damage after doses of lewisite which uniformly cause perforation in eleven days The residual damage is usually a nebula or the macular type of small scar The longer the interval before BAL is applied to the lewisite-burned eye, the less its effectiveness Although the effectiveness of BAL decreases rapidly after ten to twelve minutes,<sup>18</sup> there is still some effect after thirty minutes<sup>19</sup> Occasionally eyes will be benefited as late as forty-five minutes after contamination,<sup>21</sup> but use of BAL one hour after contamination has no beneficial effect in experiments with the doses previously described

*Repetition of Application*—There is evidence that better therapeutic results will be obtained by applying the drug once after the initial application This is of particular value in cases in which, for any reason, the casualty has not placed enough BAL in his eye on the first application<sup>20</sup>

*Vehicles for BAL*—Solvents Considered All the early work with BAL was done with the drug in liquid vehicles BAL was used in thiodiglycol (2,2'-dihydroxyethyl sulfide) by Mann and other workers<sup>15a</sup> Glycol was used both by American<sup>21</sup> and by British workers<sup>15a</sup> Hughes<sup>9b</sup> tested propylene glycol and glyceryl triacetate Calvery and others<sup>4</sup> tried dimethyl phthalate and diethyl phthalate Water has also been shown to be a suitable vehicle<sup>22</sup>

*Influence of Solvent on Therapeutic Results* It was shown that water as a solvent gave the best therapeutic results,<sup>1</sup> but such aqueous solutions are not stable<sup>5</sup> Calvery and associates<sup>4</sup> demonstrated that solutions in ethylene glycol were slightly more effective therapeutically than solutions in propylene glycol, both of which were more stable than aqueous solutions

*Toxicity of Solvent*—Water is readily tolerated by the rabbit's cornea,<sup>23</sup> while ethylene glycol is less irritating than propylene glycol The phthalates are somewhat less toxic than ethylene glycol<sup>4</sup> However, none of these solvents produces irreparable damage

17 Calvery and others<sup>4</sup> Footnote 9 *a* and *b* Mann and Pirie<sup>15a</sup>

18 Calvery and others<sup>4</sup> Hughes<sup>9b</sup> Mann and Pirie<sup>15a</sup>

19 Footnote 9 *a* and *b* Mann and Pirie<sup>15a</sup>

20 Adler, F H, Leopold, I H, Steele, W H., and Crandall, A S Personal communication to the authors

21 (*a*) Calvery, H O, Braun, H A, Vos and Fassett Personal communication to the authors, July 1943 (*b*) Calvery and others<sup>4</sup> (*c*) Adler and others<sup>9a</sup>

22 Calvery and others<sup>4</sup> Adler and others<sup>9a</sup>

23 Adler, Leopold, Steele and Crandall<sup>20</sup> Adler, Leopold and Crandall<sup>9a</sup>

*Penetrating Ability of BAL in Solvents*—With a basic bismuth dithiosalicylate ("thiol") titration method, the penetration of BAL in various solvents into the aqueous was determined<sup>5</sup> It was found that BAL penetrates most rapidly in water BAL in ethylene glycol and "cellosolve" does not reach the aqueous so quickly, although all solvents of 5 per cent concentration give adequate therapeutic aqueous levels within the first five minutes Thus greater penetration of BAL in water may account for the better therapeutic results reported<sup>5</sup> These studies indicate that BAL penetrates rapidly enough to combat lewisite

*Stability of BAL in Solvents*—The foregoing data on solvents lead to the conclusion that water is the best solvent However, iodine titration studies<sup>5</sup> have shown that BAL loses sulfhydryl groups in water much more rapidly than in ethylene glycol and that this deterioration takes place in dilute solutions more rapidly than in concentrated solutions<sup>5</sup> Investigators<sup>24</sup> were unable to demonstrate any significant loss of therapeutic efficiency of a 5 per cent solution of BAL in ethylene glycol standing at room temperature for six to eight weeks Calvery and associates<sup>21a</sup> also tested solutions of BAL in ethylene glycol at temperatures from freezing to 50 C and after bubbling oxygen through the solutions, they concluded that solutions of BAL in ethylene glycol will retain their full therapeutic efficiency for considerable periods under the temperatures and exposures to air likely to be encountered in practice

Various attempts to add preservatives to solutions of BAL in ethylene glycol have shown that these substances do not reduce its therapeutic efficiency<sup>4</sup> The agents used were thiamine hydrochloride, 0.028 per cent, and ascorbic acid, 0.028 per cent, in a 5 per cent solution of BAL in ethylene glycol Since solutions with a  $p_H$  below 6 are more stable than those with a  $p_H$  above 6, boric acid was used in the same preparations Although resultant products are slightly more stable, there is probably no real necessity for their employment No therapeutic difference could be demonstrated by using BAL solutions at  $p_H$  3, 4, 5, 6.8, 7.8 and 8 The  $p_H$  of American Reference Standard BAL is 5.8, which therefore does not require alteration for effectiveness or stability<sup>21a</sup>

*Ointment Bases*—BAL has been found to be therapeutically effective in many ointment bases after the initial observation on its action in the Friedenwald-Fuqua formula<sup>25</sup> Petrolatum,<sup>20</sup> K-Y lubricating jelly N N R, "aquaphor" (an oxycholesterol-petrolatum ointment base) and

24 Adler, F. H., Leopold, I. H., Steele, W. H., and Crandall, A. S. Personal communication to the authors, October 1942. Calvery and others<sup>21a</sup>

25 Hughes<sup>9b</sup> Friedenwald-Fuqua ointment consists of benzyl benzoate, 5 per cent, peanut oil, 37 per cent, wool fat, 8 per cent, cetyl alcohol, 10 per cent, glyceryl monostearate, 10 per cent, white petrolatum U. S. P. 25 per cent

26 Friedenwald, J., and Hughes, W. Personal communication to the authors, February 1942. Stocken and Thompson<sup>14</sup>

vanisol ointment<sup>27</sup> are other bases that have been used. However, the earlier work with ointments found them to be not quite so effective as liquid preparations<sup>28</sup>. Efforts were made to find an ointment which would stand wide changes in temperature, exposure, and so forth,<sup>11</sup> and at the same time give minimum therapeutic performance and meet standard biologic requirements. Many ointments were tried,<sup>11</sup> and after numerous tests the following ointments were chosen as satisfactory

1 United States Navy (no 13)	Percentage
Peanut oil	36.95
Wool fat U S P	8.0
Cetyl alcohol	10.0
Glyceryl monostearate	10.0
White petrolatum, soft, U S P	25.0
Benzyl benzoate	5.0
Mixed tocopherols	0.05
Medicament	5.0
2 United States Army (no 14)	
Boric acid	1.893
"Carbowax 4000"	7.592
"Carbowax 1500"	47.45
Ethylene glycol	37.96
Isoscorbic acid	0.05
Thiamine hydrochloride	0.05
Medicament	5.00
3 British (D 20)	
Diethyl phthalate	10.0
Wool fat U S P	80.0
BAL	10.0

\* "Carbowax" compounds are polyethylene glycols of high molecular weight

McLean and Cuthbert<sup>11</sup> showed that these ointments are as effective therapeutically as liquid preparations in equal concentrations, but Calvery, cited by others,<sup>11a</sup> still found the standard solution to be slightly superior to the ointments. These investigators demonstrated the low ocular irritancy of these ointments in animals and in human subjects, cited by Lazier and Sulzberger<sup>11b</sup>. It has been shown also that BAL in ointment may be applied with good therapeutic results in experimental animals<sup>29</sup> by rubbing it on the lids, making certain that some gets between them. Because of the oxidation of BAL in the presence of iron or copper, ointment must be stored in lead tubes or in glass.

#### CONCENTRATION

BAL has been shown to be effective against ocular lesions due to lewisite at 20 per cent,<sup>30</sup> 10 per cent,<sup>17</sup> 5 per cent,<sup>9a,b</sup> and 3 per cent<sup>31</sup>. Three per cent and 5 per cent solutions of BAL give just as effective a therapeutic response as a 10 per cent solution<sup>31</sup>. These results indicate

27 Adler and others<sup>10</sup>. Vanisol consists of sodium stearate, 20 per cent, cetyl alcohol, 5 per cent, glyceryl monostearate, 8 per cent, and water, 67 per cent.

28 Calvery and others<sup>21a</sup>. Adler and others<sup>10</sup>.

29 Adler and others<sup>10</sup>. Mann and Pirie<sup>15a</sup>.

30 Adler and others<sup>9a</sup>. Mann and Pirie<sup>15a</sup>.

31 Calvery and others<sup>4</sup>. Hughes<sup>9b</sup>.



that the excess of BAL over that needed for neutralization in the 5 per cent solution has no demonstrable therapeutic value, but when solutions of this strength are prepared the excess does allow for deterioration and is of value from this standpoint. No significant therapeutic difference could be demonstrated between instillation of 2 to 4 drops of 5 per cent solution of BAL in ethylene glycol and irrigation with 1 cc of the solution.<sup>81</sup> It is recognized by all workers in this field that 2 drops of a 3 or 5 per cent solution furnishes a large excess of BAL over that required to react with the lewisite likely to be present in the eye.

#### MODE OF APPLICATION

There are thus two forms, liquid and ointment, in which BAL can be successfully applied to the eye of the experimental animal. It remained to show which was the more practical for use in the field under actual battle conditions. Would it be easier for the soldier under conditions of battle to use an ointment in his eyes or a liquid? A series of tests was undertaken at the Edgewood Arsenal,<sup>82</sup> using volunteers, and putting into their eyes a tear gas of sufficient concentration to cause lacrimation and blepharospasm. After exposure to the tear gas, each subject was given either a tube of ointment or a container with liquid and instructed to place the contents into his eye. A solution of tetracaine hydrochloride was incorporated in both the liquid and the ointment, together with a solution of homatropine. The time was taken when the subject first gained relief from pain. Pupillary diameters were measured at intervals as a further check on the rapidity of action. It was found that it was far easier for the men to get the ointment into their eyes. In some cases a few drops of the solution was spilled out on the cheeks or on the ground and were lost, whereas with the ointment, if there was difficulty in getting it into the eye, the portion remaining on the lids would eventually be rubbed in. Another advantage of the ointment is that the subject could get the ointment into his eye even when lying face down. Even if the ointment tube was dropped, it could be recovered from the ground.

#### INFLUENCE OF ANESTHETICS

Repeated use of 1 per cent tetracaine hydrochloride four times daily has no deleterious effect on the course of ocular lesions due to lewisite treated with BAL.<sup>83</sup>

#### INFLUENCE OF BAL ON OCULAR LESIONS DUE TO WAR GASES OTHER THAN LEWISITE

BAL ointment has a specific effect not only on ocular lesions due to lewisite but also on those due to methylchloroarsine,<sup>33</sup> ethylchloro-

32 Friedenwald, J., Woods, A., and Adler, F. H. Personal communication to the authors, April 1943.

33 Mann, I. Personal communication, 1942.

arsine<sup>33</sup> and phenyldichloroarsine,<sup>34</sup> and it has slight beneficial effect on lesions due to mustard gas (diethyl sulfide) when used immediately after contamination of the eyes. The BAL ointment has been shown to have a beneficial effect on ocular lesions due to mixtures of lewisite and mustard gas,<sup>35</sup> both liquid and vapor, lewisite and various nitrogen mustards (general formula  $\beta$ -chloroethylamine) in liquid form<sup>36</sup> and liquid phenyldichloroarsine and mustard gas.<sup>37</sup> Irrigations have been shown to enhance the efficacy of BAL ointment against mixtures of mustard gas and lewisite when used a minute or two after applying BAL ointment.<sup>38</sup>

#### DERIVATIVES OF BAL

Attempts have been made to find a compound less toxic locally to ocular structures and more therapeutically effective than BAL for ocular lesions due to lewisite. Many compounds have been tested<sup>39</sup> on the eye. None of these compounds has been significantly more effective. However, several have been found just as good. Examples of these are

NDR 230	2,3-dimercaptopropyl acetate
NDR 287	S-(diethanolaminomethyl) ether of 1,2-dimercaptopropanol
NDR 288	2-mercapto-3-(methyl glucamino methylmercapto)-propanol
NDR 298	2,3-dimercaptopropyl ethyl ether
NDR 607	2,3-dimercaptopropyl propionate
NDR 608	2,3-dimercaptopropyl butyrate
KD 8	2-mercapto-3-(methylcarboxymethyl aminomethylmercapto)-propanol

There does seem to be no reason at present for adopting any of these derivatives for ocular use in preference to ARS BAL.

34 Davson, H, and Dunphy, E B. Personal communication to the authors, 1944. Sholz, R. Personal communication to the authors, February 1944. Adler and associates.<sup>7a</sup>

35 (a) Mann, I, and Pirie, A. Personal communication to the authors, March 1942. (b) McNamara, B P, Harrison, A E, and Guberman, E A. Personal communication to the authors, July 1943. (c) Dunphy, E B, and Uhde, G I. Personal communication to the authors, January 1944. (d) Cuthbert, M. Personal communication to the authors, March 1944. (e) Calvery, H O, Braun, H A, and others. Personal communication to the authors, August 1943. (f) Adler and associates.<sup>7a</sup>

36 Adler, F H, Leopold, I H, LaMotte, W O, Jr, and Steele, W H. Personal communication to the authors, November 1943.

37 Laughlin, R C. Personal communication to the authors, December 1943.

38 Adler, F H, Leopold, I H, and LaMotte, W O, Jr. Personal communication to the authors, February 1944.

39 Adler, F H, Leopold, I H, Steele, W H, and Crandall, A S. Personal communication to the authors, July 1943. Zingero, F F, McNamara, B P, and Harrison, A E. Personal communication to the authors, 1943. Calvery and others.<sup>21a</sup>

## USE OF PRESERVED CARTILAGE IN PLASTIC SURGERY OF THE EYE

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THE USE of preserved cartilage in plastic surgery is not new. As Peer<sup>1</sup> pointed out, this procedure was reported on more than fifty years ago but it gradually fell into disuse. Recently it has been revived, and several surgeons have reported excellent results with isografts of preserved cartilage. Thus, Brown<sup>2</sup> has used cartilage preserved in alcohol since 1928, with satisfaction in most cases. Peer<sup>3</sup> has used the same material to repair depressions in the brow, orbital socket, skull and nose. Pierce and O'Connor<sup>4</sup> employed cartilage preserved in solution of merthiolate in 182 cases, with excellent results. O'Connor<sup>5</sup> reported 375 cases in which "pickled" cartilage was used and expressed enthusiasm for its use.

The advantages of using isografts of preserved cartilage instead of autografts of fresh cartilage are manifold and have been well covered in the literature previously cited. They may be enumerated as follows:

- 1 The material is easily obtained in any desired quantity, since autopsy material is always available. Furthermore, under proper conditions it may be kept for use as long as two years.

- 2 The danger associated with obtaining autografts is obviated. Granted that the obtaining of rib cartilage is neither particularly dangerous nor technically difficult, it is nevertheless, a procedure to which some patients understandably object. I have found this to be especially true of war casualties, many of whom have sustained multiple wounds and who object to further extensive operations which might be avoided.

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1 Peer, L. A. The Fate of Living and Dead Cartilage Transplanted in Humans, *Surg, Gynec & Obst* **68** 603-610, 1939

2 Brown, J. B., cited by Peer, L. A. Cartilage Transplanted Beneath the Skin of the Chest in Man, *Arch Otolaryng* **27** 42-58 (Jan) 1938

3 Peer, L. A. Buried Grafts Used to Repair Depressions in the Brow, Eye Socket, Skull and Nose, *J. M. Soc. New Jersey* **35** 601-605, 1938

4 Pierce, G. W., and O'Connor, G. B. Reconstruction Surgery of the Nose, *Ann Otol, Rhin & Laryng* **47** 437-452, 1938

5 O'Connor, G. B. Merthiolate A Tissue Preservative and Antiseptic, *Am J Surg* **45** 563-565, 1939

3 The period of hospitalization and discomfort is shortened

4 Isografts of cartilage show less tendency than autografts to bend or curve, they heal with firmer union with the surrounding tissues and resist infection better <sup>4</sup>

Preservation of the material is simple and is based on the method first suggested by Pierce and O'Connor <sup>4</sup> When obtained at autopsy, the cartilage is cleaned of all attached tissue, including the perichondrium. It is then placed in a solution composed of 2 parts of aqueous solution of merthiolate 1:1,000 and 2 parts of isotonic solution of sodium chloride for forty-eight hours. It is then transferred to a similar fresh solution daily for three days, being cultured before each transferral and cleaned of all adherent strands of perichondrium which might have been overlooked originally. These strands have a tendency to separate after the cartilage has soaked for several days. Rarely do cultures show any growth after the first forty-eight hours. After three successive sterile cultures, the material is stored permanently at ice box temperature in a solution of 1 part of aqueous solution merthiolate 1:1,000 and 3 parts of isotonic solution of sodium chloride. Two successive daily sterile cultures are obtained before the graft is used. I have seen the material stored for several months and have found it excellent for use. O'Connor <sup>5</sup> has used material stored as long as two years.

Preserved cartilage is about as easy to work with as fresh cartilage. It has a tendency to become brittle when exposed to the air too long and should therefore be moistened with saline solution from time to time at the operating table. Otherwise it is as firm and elastic as fresh cartilage and is excellent for grafting purposes. I have used it in 17 cases with what I consider good results. In 4 of these cases preserved cartilage was used as a substitute for the tarsal plate in reconstruction and repair of the lid. In 4 cases it was used to repair the bony contours around the orbit after fracture and deformity. In 5 cases it was used to raise the orbital contents after fracture of the orbital floor. Finally, it was used in 4 cases to fill in abnormal cavities in the empty socket caused by fracture.

For the sake of brevity, only that part of the repair which concerns the use of this material is described in the following case reports.

#### REPORT OF CASES

*Repair of the Lids*—Preserved cartilage was used in 4 cases of repair of the lid to replace lost tarsal cartilage.

CASE 1—The patient had an anophthalmic left socket, fracture of the lateral wall of the orbit and loss of the outer halves of the lids and of the external canthus. Prior to admission he had had eight plastic procedures for repair of

the lids and socket. Figure 1A shows partial repair of the left upper lid with a brow pedicle flap and partial repair of the lower lid with a forehead pedicle flap. This was his status on admission. The problem was to reconstruct the lids and the outer canthus. Figure 1B shows the steps of the reconstruction, all done at one time. The remnants of the outer halves of the upper and lower lids of the left eye were split into two layers (fig 1B, 1, solid line), and the conjunctiva was mobilized. The edges of the intact medial halves of the lids were freshened and united by a surgical tarsorrhaphy. The previously rotated, hair-bearing brow pedicle was raised and mobilized (fig 1B, 2). This pedicle was a bonanza, which is not often encountered in plastic surgery. The mobilized conjunctivas of the outer halves of the lids were united by a running 0000 plain surgical gut suture. A plate of preserved cartilage, measuring 15 by 12 by 1 mm, was sewed into position between the two lids to replace the lost tarsus (fig 1B, 2, black rectangle). A sliding flap for reconstruction of the lower lid was then raised from the skin of the cheek and pulled up to complete the repair of the lower lid (fig 1B, 3). The rectangle with the diagonal lines merely indicates the position of the cartilage plate between the skin and the conjunctiva.

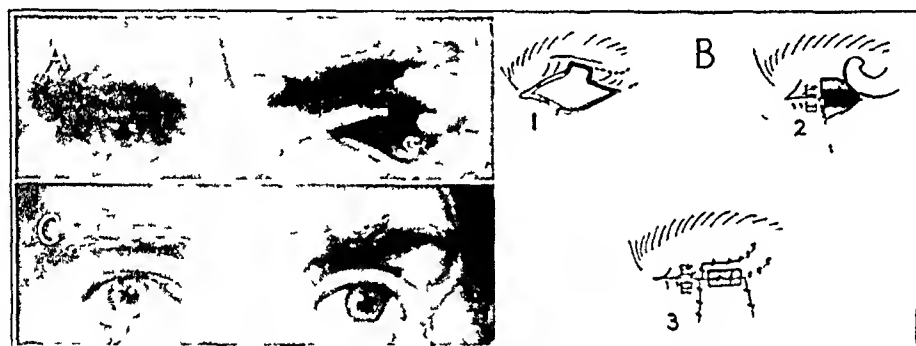


Fig 1 (case 1)—A, appearance of the patient on admission. B, steps in the repair. (1) Outer halves of the lids are split, and the conjunctiva is mobilized. The margins of the inner halves of the lids have been freshened. (2) The inner halves of the lids are sutured together. The conjunctivas of the outer halves are united, and preserved cartilage graft is sewed in position (indicated by the black rectangle). Skin pedicles for reconstruction of the lids are raised. (3) Appearance on completion of operation, with skin pedicles sutured over the graft (indicated by the rectangle). C, result before revision of scars.

and does not show the exact size of the graft. Figure 1C shows the result four weeks after removal of the tarsorrhaphy sutures and before revision of the scars.

CASE 2—On admission, the patient had an anophthalmic right socket with loss of the inner half of the right lower lid, as well as symblepharon (fig 2A). The first step in the repair was the fashioning of a small plate of preserved cartilage, measuring 12 by 5 by 1 mm. An incision was then made in the conjunctiva of the lower lid (fig 2B, 1, vertical solid line) and the conjunctiva undermined nasally. The cartilage plate was then slipped into position, as shown. Two weeks later the conjunctival remnants of the medial portion of the lower fornix with its now adherent cartilage plate was dissected up. The medial half of the right upper lid was split into two layers just far enough to give two edges and was denuded of epithelium. The edges of the outer halves

of the lids were also denuded of epithelium and united by a tarsorrhaphy. The conjunctivas of the medial halves were united by a running suture of 000000 black silk, and a sliding flap of skin from the cheek was outlined and pulled up to complete the reconstruction of the skin of the lid (fig 2 *B*, 2). The skin flap was sutured to the skin-muscle layer of the medial half of the upper lid by a running suture of 0000 black silk (fig 2 *C*). Six weeks later grafting of lashes from the opposite brow was done. The lids were separated six weeks

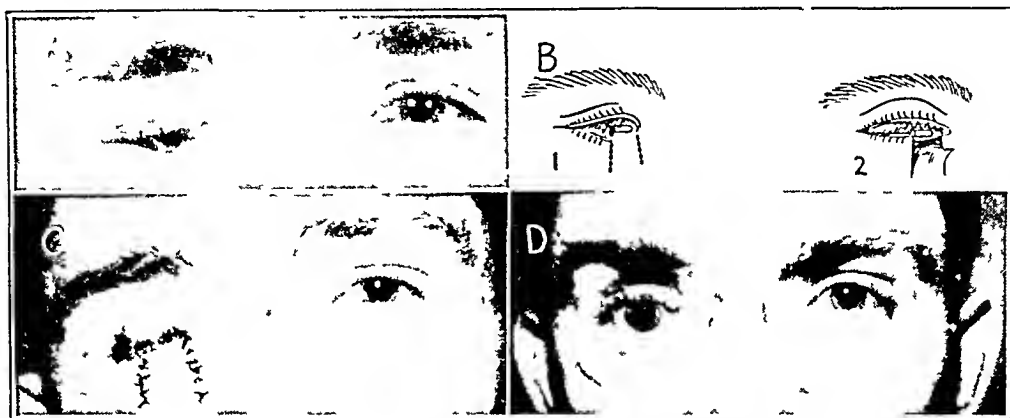


Fig 2 (case 2)—*A*, appearance of the patient on admission. *B*, method of repair: (1) planting of preserved cartilage graft under the conjunctiva (broken rectangle), (2) reconstruction of the inner half of the lower lid (see text). *C*, appearance on the sixth day, before removal of the skin sutures. The tarsorrhaphy sutures were removed on the twelfth day. *D*, result. The lashes are beginning to grow.

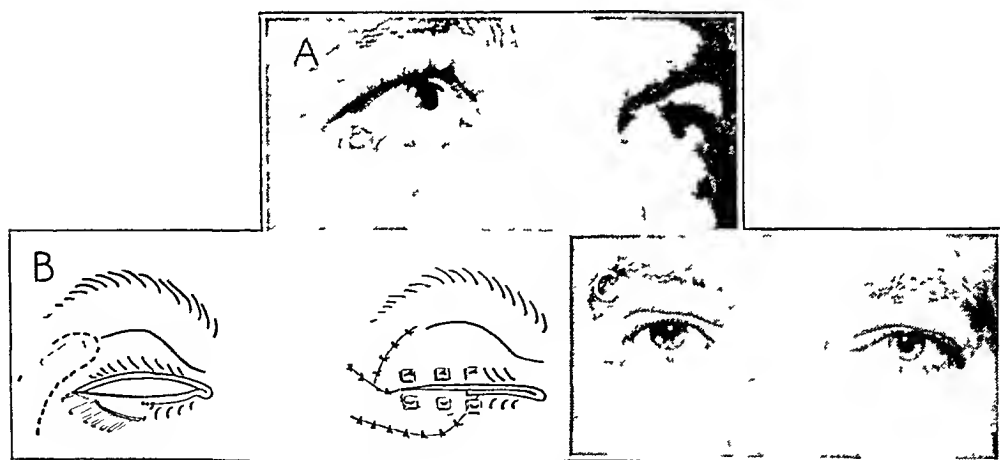


Fig 3 (case 3)—*A*, tumor of the right lower lid. *B*, method of repair: (Left) Raising of delayed pedicle flap from the upper lid and planting of preserved cartilage graft. Excision of the full thickness lid with the tumor mass was done two weeks later. (Right) Appearance of lids on completion of repair. *C*, result nine days after separation of the lids.

later. The socket was shallow and had to be deepened by an additional mucous membrane graft, but the lid was adequate cosmetically and functionally (fig 2 *D*).

CASE 3—The patient gave a history of a growth on the right lower lid for twenty(?) years. There had been an appreciable increase in the size of this

growth during the last two years (fig 3 *A*) As preliminary to the repair a pedicle flap was raised from the skin of the right upper lid, and a plate of preserved cartilage measuring 14 by 5 by 1 mm was fashioned and slipped under the skin pedicle before it was sutured back into place (fig 3 *B*, 1)

Fourteen days later the outer portion of the right lower lid was completely resected The excised fragment of full thickness lid measured 16 by 15 mm at its widest point The edge of the remaining conjunctiva in the outer half of the lower fornix was undermined and mobilized The edge of the outer half of the right upper lid was denuded of epithelium and split into two layers in order to give two edges These were not mobilized The conjunctiva from the lower fornix and the tarsoconjunctiva of the upper lid were united by a running suture of 000000 black silk The pedicle flap previously fashioned in the upper lid was raised, together with its adherent cartilage plate The under surface of the cartilage was found to be well vascularized This pedicle was then swung down into the skin dehiscence of the lower lid and sutured into

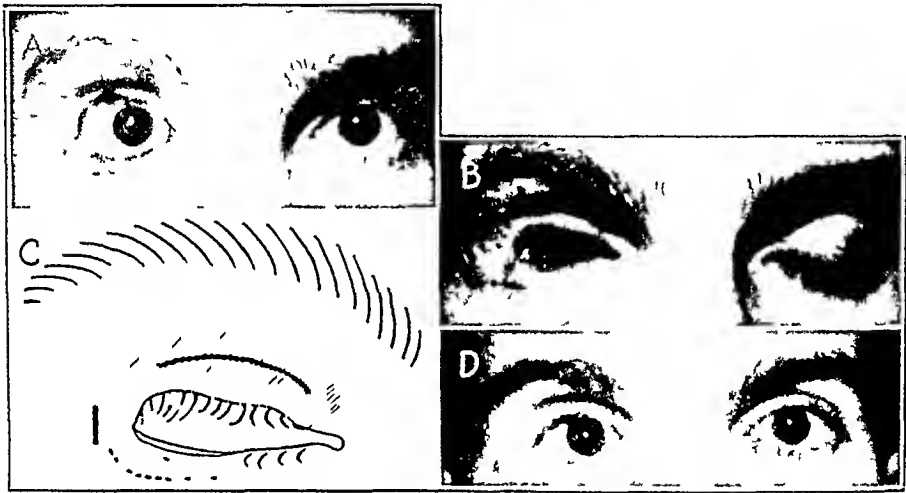


Fig 4 (case 4) —*A*, lagophthalmos of the upper and lower lids of the right eye *B*, same without prosthesis and with the eyes closed *C*, position of cartilage plate grafted under the skin of the lower lid (dotted area) The solid vertical line shows position of the incision *D*, appearance six weeks later

position Three mattress sutures of black silk tied over pegs furnished additional support to the lower lid and graft (fig 3 *B*, 2) Six days later the skin sutures were removed The tarsorrhaphy sutures were removed in twelve days Six weeks later the lids were separated (fig 3 *C*)

The pathologic diagnosis on examination of the excised portion of the lid was basal cell carcinoma At the time of writing, twenty months later, the patient is doing well

**CASE 4**—The patient presented an empty right socket with lagophthalmos, due to shortening of the upper and lower lids (fig 4 *A*) The upper lid was considerably narrowed, and the lower lid, which had been reconstructed, was too thin and sagged from lack of support (fig 4 *A* and *B*) At the time of repair, the right upper lid was first widened by means of a free whole skin graft taken from the left upper lid Four weeks later a crescentic piece of preserved cartilage was fashioned This was 1 cm wide and 1 mm thick, the vertical arm

measured 8 mm, and the horizontal arm, 18 mm (fig 4C, dotted area) An incision was made about 10 mm temporal to the outer canthus, the skin undermined, the cartilage plate slipped under the skin and the wound closed with two black silk sutures Figure 4D shows the lids in normal position, six weeks later

*Repair of Defects Around the Socket*—Bony defects around the orbit often give unsightly depressions and disturbances of contour which are disfiguring If the defect is great, bone grafting should be done In repair of the smaller defects, however, cartilage grafts suffice and are well adapted to this purpose In 4 cases defects were repaired in this manner, 2 of which are reported in detail

CASE 5—On admission the patient had an anophthalmic right orbit, cicatricial ectropia of the right upper and lower lids and loss of the upper fornix, due to cicatrices and synechias (fig 5A) He had an extensive defect of the right

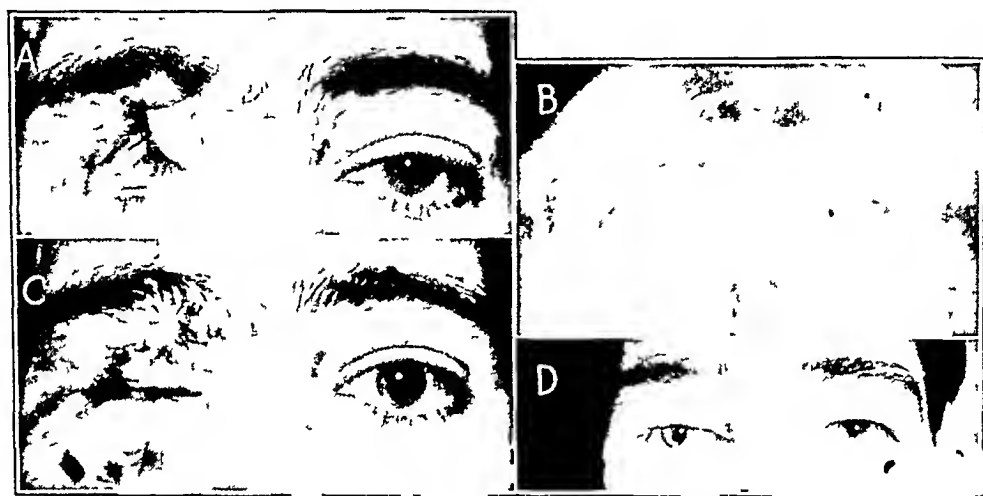


Fig 5 (case 5)—A, appearance of the patient on admission Note the depression under the medial half of the brow B, roentgenogram of the skull, showing defect of the frontal bone C, appearance immediately after repair of the depression with preserved cartilage D, result eight weeks after operation Note absence of depression

frontal bone which followed operation for removal of multiple metallic foreign fragments (fig 5B) At the time of repair of the lid the wound in the upper lid was laid open widely and the bony defect filled in with a plate of preserved cartilage (fig 5C) The immediate result is shown in figure 5D

CASE 6—The patient had a deep bony depression over the right zygoma (fig 6B), as well as an anophthalmic right socket and a medial notch of the right lower lid (fig 6A) The bony defect was repaired by laying open the soft tissues and fashioning an inlay of preserved cartilage cut to pattern This cartilage plate was approximately 1 cm thick at the deepest point The wound was closed in layers, the muscle tissue with surgical gut and the skin with 0000 black silk sutures The notch in the lid was repaired at the same time Figure 6C shows the result of repair five days later The appearance five weeks later is shown in figure 6D



*Repairs of the Orbit*—In 9 cases preserved cartilage was used in the orbit to fill out defects due to fractures. In 5 of these cases there was depression of the orbital floor and contents. In 1 of these cases the socket was anophthalmic, and the prosthesis required raising. In the other 4 cases there was ptosis of the globe. Two cases are reported in detail, with photographs.

In 4 cases preserved cartilage was used in an anophthalmic socket to fill in abnormally large cavities preceding reconstruction of the socket. In 2 of these cases a cartilage plate was used. In the other 2 cases chips of preserved cartilage were used to fill in large, cystlike, irregular spaces.

CASE 7—On admission the patient presented ptosis of the left globe with enophthalmos, blepharoptosis and scarring of the tissues of the forehead, pulling his left brow up (fig 7A). He had fractures of the left portion of the frontal

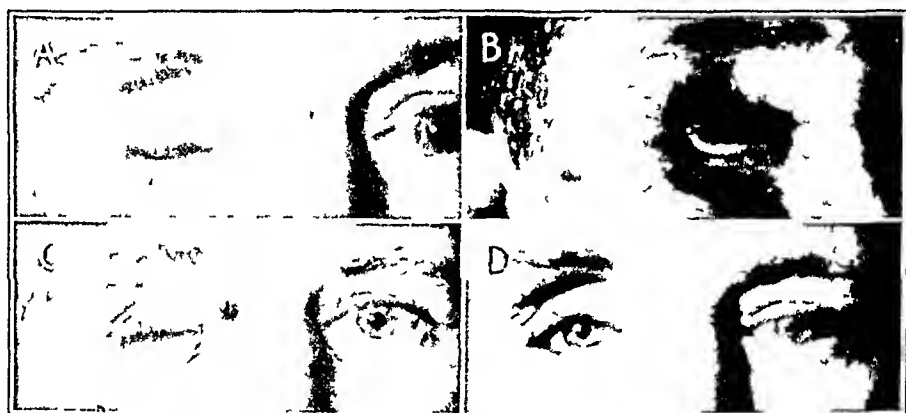


Fig 6 (case 6)—A and B, appearance of the patient on admission, C, appearance five days after repair of bony defect over the right zygoma with a preserved cartilage plate, D, final appearance five weeks later.

bone which extended into the posterior parietal region and the frontal ridge, with resultant depression and deformity of the left orbit (fig 7B). Vision was 20/20 in each eye, his chief complaint, of course, was diplopia. At operation, the lower orbital rim was exposed by an external incision, the periosteum of the orbital floor was lifted and a plate of preserved cartilage was inserted to elevate the eyeball. The wound was closed in layers. Figure 7C shows the relative position of the eyes five days later, before removal of the sutures. Figure 7D shows the patient thirteen days after operation. There was a residuum of 6 prism diopters of right hypertropia but no diplopia in the primary position.

CASE 8—On admission, the patient had ptosis of the left globe with a deep depression above the eye as a result of sagging of the orbital contents. The eye was amblyopic (fig 8A). Repair was made exactly as in case 7. The result, ten days after operation, is shown in figure 8B. Here, again, the disappearance of the supratarsal depression is to be noted.

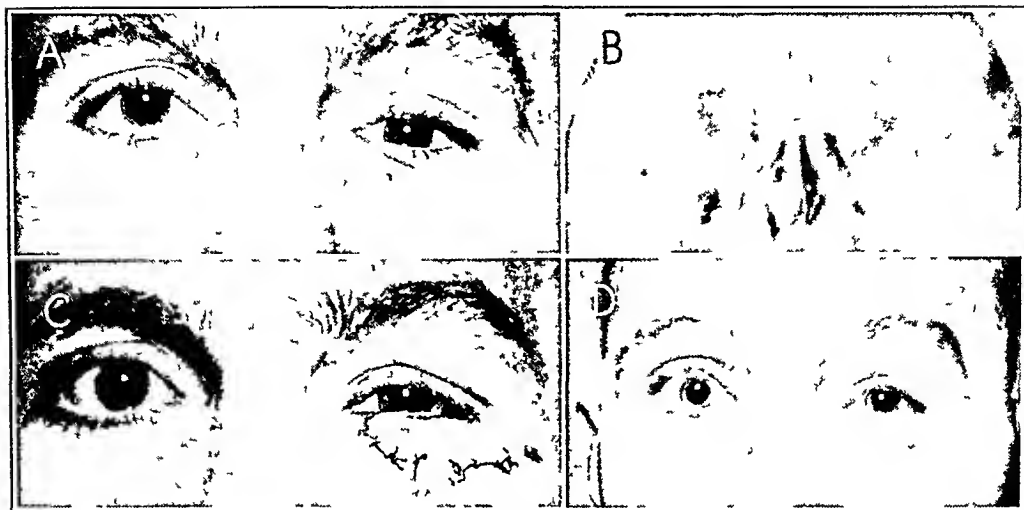


Fig 7 (case 7) —*A*, ptosis and enophthalmos of the left globe, *B*, roentgenogram of the orbit seven months after injury, *C*, appearance five days after operation, *D*, result thirteen days after operation. Note that the eyes are on a level but that the enophthalmos and blepharoptosis persist. The depression beneath the left brow has disappeared.



Fig 8 (case 8) —*A*, ptosis of the left globe due to fracture of the orbital floor, *B*, result ten days after repair.

## COMMENT

Preserved cartilage has been used most extensively, of course, by the plastic surgeon in reconstructions of the nose, ear, forehead, chin and other facial structures. This will probably always remain its greatest sphere of usefulness. But it can also be used effectively by the ophthalmic surgeon in reconstructions in and about the orbit, as reported.

Since preserved cartilage is a "dead" tissue, the question of what happens to it after grafting into the host is pertinent and germane. The most recent experimental study was carried out by Peer,<sup>1</sup> who studied the fate of living (autograft) and dead (isograft) human cartilage planted under the abdominal skin of human subjects. He found that fresh rib cartilage buried under the skin of its own human host survives for periods as long as six years and neither increases nor decreases in size. In the case of preserved human rib cartilage buried in other human hosts the grafts showed microscopic invasion by the surrounding host tissues and areas of absorption. There were also areas of calcification and early formation of bone. This process, however, was very slow, and "the bulk of the graft was still present two years after transplantation." So much for actual pathologic studies.

Clinically, Pierce and O'Connor<sup>4</sup> followed 182 cases for five years after using preserved cartilage grafts and stated that they prefer them to autografts. O'Connor<sup>5</sup> followed 375 cases with isografts of cartilage and found that the grafts had retained their original size and identity in all but 7 cases. Only 1 graft was completely lost, owing to infection. In my series, 2 patients were followed for eighteen months, 3 were seen after twelve months, and the rest were followed for at least six months. No visible or palpable change in the grafts was noted. There were no infections.

It seems to me that the ultimate histologic fate of the cartilage isograft is of less import to the ophthalmic surgeon than to the plastic surgeon. If absorption of a graft used to reshape a nose or chin occurs, the result may be failure, with further surgical repair necessary. On the other hand, assuming that a thin plate of preserved cartilage implanted into a lid, for instance, is ultimately completely absorbed and converted into dense fibrous tissue, such a change, according to all available evidence, would not occur for several years, if at all. Furthermore, the resultant tissue structure is not unlike that of the tarsal "cartilage," which furnishes ample support to the lid. The object of the surgical procedure has been accomplished in any case. The use of the isograft, moreover, has obviated the necessity of taking cartilage from the patient's ear or rib, or tarsus from another lid, and has simplified and shortened the operation for both surgeon and patient.

Spaeth<sup>6</sup> stated that "cartilage and corneal tissues are perhaps the only grafts which can be used with success as an isograft. All other grafts are likely to result in failures unless they are homografts" Recent reports seem to show that the field of usefulness of isografts may not be so narrow. Thus, Filatov<sup>7</sup> and his school have done successful grafting with refrigerated tissues. Recently Rosen<sup>8</sup> reported a successful transfer of the conjunctiva from a cadaver. The tremendous need for restorative surgery resulting from the recent war has stimulated much work and experimentation in this field and has furnished ophthalmic surgeons with an unparalleled opportunity to learn and profit from it. It may be that as a result of this work the whole field of isografting and heterografting will have to be reevaluated. There is no reason that more ophthalmic surgeons should not take a hand in this work.

Certainly, in selected cases I can think of no important objections to the use of cartilage isografts in plastic surgery of the eye. I can see several valid reasons for its use. I hope more oculists will try it and report their results.

#### SUMMARY AND CONCLUSIONS

Seventeen cases are reported in which preserved cartilage was used as an isograft. In 4 cases it was used in reconstruction of the lid to replace lost tarsal "cartilage." In another 4 cases it was used to repair bony depressions outside the orbit. In 9 cases preserved cartilage was used inside the orbit to repair depressions of the floor and walls due to fractures. The results were good.

The advantages of using preserved cartilage in reconstruction of the lids and the socket are enumerated.

In selected cases there seems to be no contraindication to the use of preserved cartilage in plastic surgery of the eye.

Mr. Herbert M. Krauss made the drawings illustrating the technic of the various operative procedures.

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6 Spaeth, E. B. *The Principles and Practice of Ophthalmic Surgery*, Philadelphia, Lea & Febiger, 1944, p. 88.

7 Filatov, V. P. *Tissue Therapy in Ophthalmology*, *Am. Rev. Soviet Med.* 2:53-66, 1944.

8 Rosen, E. *Heterogeneous Conjunctival Transplantation*, *Am. J. Ophth.* 29:193-195, 1946.

## PENETRATION OF LOCALLY APPLIED BAL INTO THE ANTERIOR CHAMBER OF THE RABBIT EYE

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AND

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WHEN it was found that the use of BAL (2,3-dimercaptopropanol) was of considerable value, both prophylactically and therapeutically, in the treatment of eyes exposed to lewisite (2-chlorobis(2-chlorovinyl)arsine) burns,<sup>1</sup> the problem arose as to what extent BAL penetrated through the normal or the abnormal cornea and into the anterior chamber. Since BAL essentially neutralizes the toxic heavy metal arsenic in lewisite burns, the possibility that BAL might be of importance in treatment of intoxications due to other metals, such as lead, mercury and cadmium, also warranted this study.

An accurate, yet practical, method for the quantitative estimation of BAL was investigated. The cobalt nitrate test of Kensler and Rhoads,<sup>2</sup> the porphyrindim test of Greenstein<sup>3</sup> and the iodometric titration of sulfhydryl groups, as used by Woodward and Fry for glutathione, were tried. The iodometric titration was chosen and used exactly as recommended by Woodward and Fry,<sup>4</sup> except that instead of a 0.001 normal solution of potassium iodate we employed a 0.0005 normal solution of potassium iodate. Because of the extreme dilution of this reagent, it was necessary to check on the accuracy of the method by titrating it against a known dilute solution of BAL to determine whether the method could actually be employed for this compound.

Table 1 shows the values for the sulfhydryl groups obtained, expressed in cubic centimeters of 0.0005 normal potassium iodate, when

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The work described in this paper was done under a contract recommended by the Committee on Medical Research, between the office of Scientific Research and Development and the University of Pennsylvania.

1 Personal communications to the authors: Stocken, L. A., and Thompson, R. H. S. (1941); Mann, I., Pirie, A., and Pullinger (1941); Clark, A. J., Robson, J. H., and Scott, G. I. (1941); Adler, F. H., Leopold, I. H., Crandall, A. S., and Steele, W. H. (1942); Hughes (1942).

2 Kensler, C. J., and Rhoads, C. P. Personal communication.

3 Greenstein, J. *J. Biol. Chem.* **125**: 501, 1938.

4 Woodward, G. E., and Fry, E. G. *J. Biol. Chem.* **97**: 465, 1932.

the solution was titrated against aqueous solutions of BAL containing 0.04, 0.06, 0.1, 0.16 and 0.2 mg, respectively, per cubic centimeter. The table also includes figures for the same concentrations of BAL in ethylene glycol and for ethylene glycol alone. From these figures, a graph has been plotted showing that practically a straight line is obtained, which corresponds with the straight line prepared from calculated theoretic values (graph). The difference between the actual readings and the theoretic ones may be explained on the basis of the purity of the sample used and on errors in technic, which for these

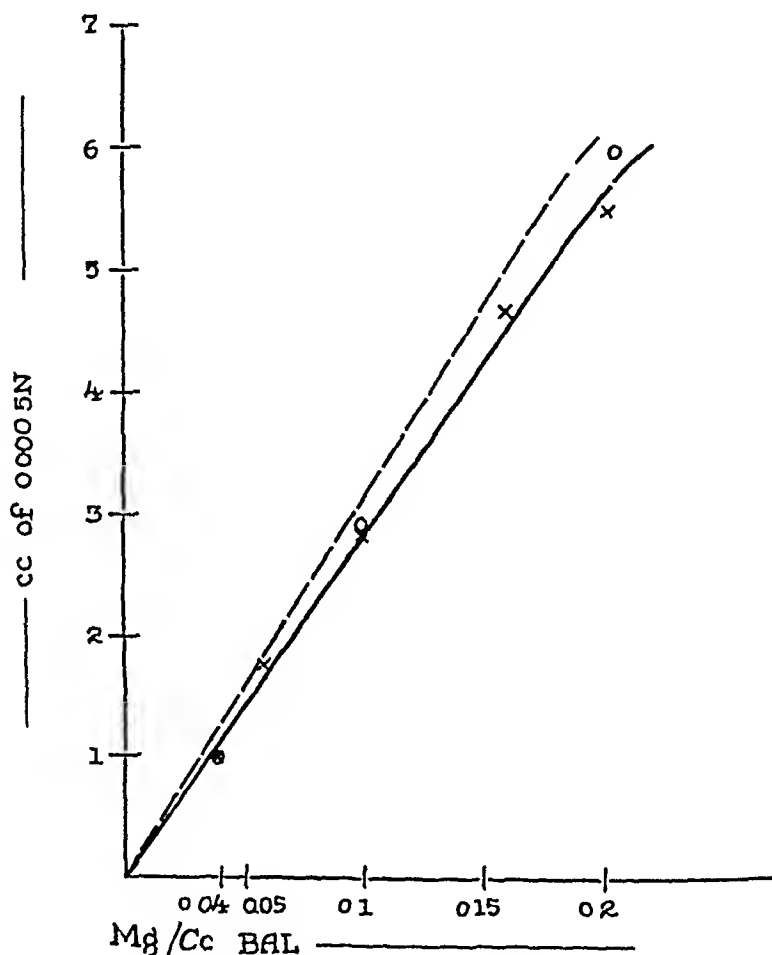
TABLE 1—*Standardization of 0.0005 Normal Solution of Potassium Iodate Used in Titration of BAL*

Aqueous solution	Concentration of BAL, Mg /Cc					
	0.00	0.04	0.06	0.1	0.16	0.2
	Readings in Cc. of 0.0005/N Potassium Iodate					
	0.13	1.17	1.88	3.10	5.035	5.61
	0.11	1.16	1.90	3.10	4.905	5.70
	0.12	1.17	1.98	2.98	4.820	5.45
	0.14	1.18	1.95	2.99	4.755	5.75
	0.11	1.15		3.00	4.70	5.70
		1.14		3.01	4.665	5.51
		1.12		3.00		5.61
		1.11		3.00		5.60
				2.97		5.59
				2.99		5.55
				3.10		
Average value	0.12	1.13	1.92	3.02	4.813	5.607
Average range	±0.02	±0.04	±0.06	±0.08	±0.148	±0.15
Ethylene glycol solution	0.20	1.310		3.19		6.10
	0.22	1.275		3.185		6.13
		1.300		3.17		6.30
		1.295				
Average value	0.21	1.295		3.181		6.17
Average range	±0.02	±0.02		±0.01		±0.13

titrations were never greater than 5 per cent, and in the majority of readings were less than 3 per cent.

Using this method for determination of BAL, a dilute solution containing 10 mg of BAL in 50 cc of water was prepared, and various concentrations of this solution were titrated at varying time intervals. The data from these experiments are included in table 2. These results indicate that there is a definite loss of sulfhydryl groups when BAL is dissolved in a dilute aqueous solution and allowed to stand. This loss is practically complete within forty-eight hours. When BAL is dissolved in ethylene glycol in the same concentration, as the findings on table 2 indicate, there is practically no loss in forty-eight hours. If a 1 per cent aqueous solution is tested after ten days, deterioration can be noted, but it is slight.

Before this test could be used for determination of the degree of penetration of BAL, it was necessary to determine the amounts of solution of potassium iodate required to react with the sulfhydryl-bearing compounds of normal aqueous humor. The 12 eyes of 6 rabbits were used for this test, and the values are recorded in table 3. It can be seen that the greatest range for values of normal aqueous



Comparison of the theoretic and obtained values for BAL by the iodometric titration method. In this graph, crosses indicate values for aqueous solution, circles, values for solutions in ethylene glycol, the broken line, theoretic values for 100 per cent pure BAL, and the solid line, values actually obtained for BAL in aqueous solution and in solution in ethylene glycol.

humor were from 3.98 to 8.5 cc of 0.0005 normal solution of potassium iodate for each cubic centimeter of aqueous humor, but that the difference between the two eyes of the same rabbit was never greater than 0.42 cc of 0.0005 normal solution of potassium iodate for each cubic centimeter of aqueous humor. As the data in table 3 indicate,

the previous use of 2 drops of 2 per cent ethyl morphine hydrochloride failed to increase the values obtained. It made no significant difference in the values obtained with normal aqueous humor whether or

TABLE 2—*Loss of Sulfhydryl Groups<sup>†</sup> in Dilute Aqueous Solution of BAL Compared with Loss in Dilute Solutions of BAL in Ethylene Glycol\**

Aqueous Solution, Mg /Cc			Solution in Ethylene Glycol, Mg /Cc		
0 04	0 1	0 2	0 04	0 1	0 2
0 0005/N Potassium Iodate, Cc			0 0005/N Potassium Iodate, Cc		
1 13	3 02	5 60	1 295	3 18	6 17
1 Hour Later					
1 03	2 75	5 38			
2 Hours Later					
0 946	2 68	5 23			
24 Hours Later			24 Hours Later		
0 78	2 30		1 30	3 05	6 20
30 Hours Later					
0 25	0 35	0 54			
48 Hours Later			48 Hours Later		
0 12	0 15		1 25		6 15

\* Values for the sulfhydryl group are expressed in terms of cubic centimeters of 0 0005 normal solution of potassium iodate. Each recorded value is an average of at least five readings, all falling within a 3 per cent error.

TABLE 3—*Values for Sulfhydryl Groups for Normal and for Secondary Aqueous\**

Rabbit 142	Cc	Rabbit 142 (1 hr later)	Cc	Rabbit 115 (long stand- ing mustard gas burn with keratitis)	Cc
O D	4 40	O D	10 60	O D	6 325
O S	3 98	O S	10 42	O S	5 30
Rabbit 143		Rabbit 143 (1 hr later)			
O D	5 24†	O D	11 10		
O S	5 50†	O S	13 80		
Rabbit 145					
O D	5 5 †				
O S	5 1 †				
Rabbit 146					
O D	4 98				
O S	5 00				
Rabbit 147					
O D	8 5				
O S	8 1				
Rabbit 148					
O D	7 68				
O S	7 35				

\* Values are expressed in cubic centimeters of 0 0005 normal potassium iodate required for each cubic centimeter of aqueous. The greatest range from one animal to another is 3 98 to 8 5 cc. The greatest range in any one animal between the right and the left eye is 0 42 cc.

† Eyes received 2 drops of 2 per cent ethyl morphine hydrochloride before puncture of the aqueous.

‡ Proteins precipitated with sulfosalicylic acid.

not the proteins were precipitated before titration. However, when secondary aqueous was titrated without precipitating the proteins, there was a definite increase in the number of cubic centimeters of the



solution of potassium iodate required per cubic centimeter of aqueous humor. These figures are also included in table 3. An animal in which chronic keratitis had been induced with mustard gas (2-chloroethylsulfide) failed to show concentrations in the aqueous humor above those obtained for normal eyes. The probable substances in the aqueous humor which give titration values with this test are ascorbic acid, glutathione and cysteine. With the foregoing data, studies of the penetration of BAL into the aqueous humor of normal rabbit eyes were then undertaken.

Five per cent BAL in water was applied to the conjunctival cul-de-sac of 3 rabbits. Five minutes after the application of 4 drops of

TABLE 4—*Penetration of Solutions of BAL in Water and in Ethylene Glycol into the Anterior Chamber\**

	Time of Limbal Puncture After Application					
	5 Minutes		15 Minutes		30 Minutes	
	Rabbit 136	Cc	Rabbit 142	Cc	Rabbit 139	Cc
5% BAL in water (in both eyes)	O D	21.23	O D	11.15	O D	11.00
	O S	19.40	O S	13.00	O S	10.40
	Rabbit 137		Rabbit 148		Rabbit 150	
	O D	18.85	O D	13.07	O D	5.92
	O S	21.60	O S	10.00	O S	8.00
	Rabbit 140					
	O D	25.00				
	O S	7.81				
	Rabbit 152		Rabbit 157		Rabbit 151	
	O D	14.15	O D	4.56	O D	5.90
	O S	Lost	O S	5.03	O S	5.80
	Rabbit 154				Rabbit 153	
5% BAL in ethylene glycol (in both eyes)	O D	8.37			O D	9.45
	O S	7.41			O S	10.10
	Rabbit 158				Rabbit 156	
	O D	10.85			O D	8.80
	O S	6.53			O S	7.52

\* Values are expressed in cubic centimeters of 0.0005 normal potassium iodate per cubic centimeter of aqueous.

this solution, the eyes were thoroughly irrigated with isotonic solution of sodium chloride, and punctures into the anterior chamber made, with the rabbit under ether anesthesia, titrations were made immediately on these samples of aqueous humor. With the same method, 4 drops of 5 per cent BAL in ethylene glycol were placed in the conjunctival cul-de-sac, and the amount of the drug in the aqueous humor was evaluated. In other rabbits, the penetration of BAL into the anterior chamber after fifteen and thirty minutes was similarly determined. The results of these studies are presented in table 4. It is evident that the concentration of BAL in the anterior chamber was greater when water was used as a vehicle than when ethylene glycol was used.

Because it has been shown that the range for normal aqueous humor varies from 3.98 to 8.5 cc of 0.0005 normal solution of potassium iodate per cubic centimeter of aqueous humor, it might be argued that the figures in table 4 may represent not the actual difference in the degree of penetration of BAL in aqueous solution as compared with that in solution in ethylene glycol, but only the variations to be found in normal aqueous humor. However, it has been shown that the range of variations for normal aqueous humor between the two eyes of the

TABLE 5—*Penetration of BAL in Aqueous, Ethylene Glycol and Ointment Vehicles*

	Time of Limbal Puncture After Application			
	5 Minutes		30 Minutes	
Water and ethylene glycol *	Rabbit 162	Cc	Rabbit 161	Cc
	O D	17.70	O D	17.17
	O S	9.24	O S	7.77
	Rabbit 163		Rabbit 164	
	O D	20.83	O D	5.99
	O S	14.52	O S	5.50
	Rabbit 168			
	O D	27.6		
	O S	6.7		
	Rabbit 171			
	O D	14.65		
	O S	9.55		
K Y jelly and Friedenwald (Fuqua)†	Rabbit 172			
	O D	12.25		
	O S	9.55		
	Rabbit 160		Rabbit 155	
	O D	12.81	O D	7.40
	O S	6.08	O S	6.15
	Rabbit 165		Rabbit 159	
	O D	15.22	O D	4.65
	O S	10.03	O S	4.60
	Rabbit 169			
	O D	11.26		
	D S	7.60		

\* The right eye received 5 per cent BAL in aqueous solution, and the left eye, 5 per cent BAL in solution of ethylene glycol.

† The right eye received 5 per cent BAL in K Y jelly, and the left eye, 5 per cent BAL in modified Friedenwald Fuqua ointment.<sup>5</sup>

same rabbit is always less than 0.4 cc of 0.0005 normal solution of potassium iodate, so 4 drops of a 5 per cent solution of BAL in water were placed in the right eye of 5 rabbits and 4 drops of a 5 per cent solution of BAL in ethylene glycol were placed in the left eyes of the same rabbits. Punctures into the anterior chamber were made five minutes later, and titrations made immediately, the values are recorded in table 5. It can be seen that the solution of BAL in water gave consistently higher concentrations of BAL in the aqueous humor than the solution in ethylene glycol.

The concentrations of BAL in the anterior chamber thirty minutes after instilling the preparations in water and in ethylene glycol showed

no significant difference in penetration of the two solutions. These data are included in tables 4 and 5.

Penetration of 5 per cent BAL in ointment was also tested. Five per cent BAL in K-Y lubricating jelly N N R was placed in the right eyes and the same quantity of 5 per cent BAL in a modified Friedenwald (Fuqua) ointment<sup>5</sup> in the left eyes of 3 rabbits. The cul-de-sacs were thoroughly irrigated with isotonic solution of sodium chloride after five minutes and punctures into the anterior chamber made. Titrations done immediately showed that high concentrations of BAL in the aqueous humor were obtained when K-Y jelly was the vehicle. When these titrations were made thirty minutes after applying BAL in the ointment bases, no significant difference could be demonstrated between the values for the two ointments.

#### COMMENT

It is evident from these data that solutions of BAL in water and in ethylene glycol penetrate through the cornea into the anterior chamber. The penetration from a water vehicle was more rapid than that from an ethylene glycol vehicle. Likewise, a water-containing ointment allowed greater penetration than did a nonaqueous base. However, aqueous solutions of BAL are unstable, and for the majority of practical uses the stability of the preparation will be more important than the rate of penetration.

#### CONCLUSIONS

- 1 Aqueous solutions of BAL (2,3-dimercaptopropanol) deteriorate more rapidly than solutions in ethylene glycol, at least so far as sulfhydryl groups are concerned, and the more dilute the aqueous solutions of BAL the more apparent the loss.

- 2 Greater penetration into the aqueous humor occurs from the use of a 5 per cent solution of BAL in water than from the use of a 5 per cent solution of BAL in ethylene glycol.

- 3 BAL penetrates more readily from a water-containing base, such as K-Y jelly, than it does from a nonaqueous base, such as Friedenwald-Fuqua ointment.

Hospital of the University of Pennsylvania (4)

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<sup>5</sup> The modified Friedenwald-Fuqua ointment contains peanut oil, 36.95 per cent, wool fat, 8 per cent, cetyl alcohol, 10 per cent, glyceryl monostearate, 10 per cent, white petrolatum, soft, 25 per cent, benzyl benzoate, 5 per cent, mixed tocopherols, 0.05 per cent, and medicament, 5 per cent.

## ATROPHY OF THE OPTIC NERVE ASSOCIATED WITH TABES DORSALIS AND WITH GLAUCOMA

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IN A SMALL percentage of cases of tabes dorsalis, about 15 per cent according to Uhthoff,<sup>1</sup> bilateral progressive atrophy of the optic nerve can be detected by the pronounced pallor of the optic disk. It is an early sign, preceding all other manifestations of tabes, even the subjective disorder of vision. Its salient feature is the atrophy of the nerve head, without any noticeable change in the arteries. It is to be differentiated from another, similar, type of atrophy, in which in addition to the discoloration of the papilla the arteries are narrowed, owing to an inflammatory process involving both the arterial wall and the surrounding tissue. Whereas in the latter type of atrophy syphilis of the meninges is suggested as the underlying cause, the pathogenesis of the first type is obscure. From the clinical point of view, it is worth while to note the slow but relentless progress of visual disturbances; the constant bilaterality, the early reduction of color appreciation (for red and green), the early failure of vision to adapt itself to the dark, the lack of involvement of any of the cranial nerves, such as is frequently seen in cases of syphilitic basilar meningitis, the presence of the syphilitic infection many years before the atrophy of the optic nerve, and the classic Argyll Robertson sign. Later, absolute fixity of the pupils may occur. The pupils, sometimes anisocoric, are miotic—in juvenile tabes often mydriatic. Their response to atropine, according to my personal experience, is slow. Ectopia of the pupils is rare. In the majority of cases a progressive peripheral contraction of the visual fields takes place, central vision being spared for a long time. Occasionally, however, central scotoma or binasal or temporal, or even bitemporal, hemianopsia has been recorded. The hemianopsia reminds one of the well known visual defects found with disorders of the pituitary gland. Complicating syphilis of the meninges in the region of the chiasm may play a role of importance in some instances. Oliver,<sup>2</sup> in his statistical studies, found that 90 per cent of the cases of tabetic atrophy of the

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1 Uhthoff, W., in Graefe, A., and Saemisch, T. *Handbuch der gesamten Augenheilkunde*, ed 2, Leipzig, W. Engelmann, 1911, vol 11, chap 22.

2 Oliver, C. A. *Am J M Sc* 120 49, 1900.

optic nerve were encountered in males. The course of the tabes in cases of amaurosis is surprisingly mild ("Benedikt's<sup>3</sup> law")

As the basis of the condition there is undoubtedly an anatomic lesion of the optic pathways, involving in later stages the entire diameter of the optic nerve, the axons as well as the myelin sheaths. The primary site and the nature of this lesion are still *sub judice*. The pathologic observations recorded in the literature are confusing. Leri<sup>4</sup> failed to observe any changes in the ganglionic layer of the retina, although almost every normal fiber in the optic nerve had disappeared. Degenerative alterations of the optic tract in the region of the lateral geniculate body could not be demonstrated by Léri,<sup>4</sup> Moeli<sup>5</sup> or Holden<sup>6</sup>. In an inflammatory parenchymatous process of the optic nerve, secondary degeneration of the ganglion cells of the retina or of the external geniculate body is to be expected. Stargardt<sup>7</sup> expressed the belief that there might occasionally be neurotic degeneration in the optic tracts or in the corpus geniculatum laterale. His conclusions, however, are not convincing, since in most of his cases the eyegrounds were normal. In recent years in 4 cases of complete bilateral blindness associated with tabes Deutsch<sup>8</sup> observed atrophy of certain components of the corpus geniculatum laterale, whereas the geniculocortical neurons were intact. These observations were confirmed by Hechst<sup>9</sup>. One might, therefore, be justified in suggesting that atrophy of the optic nerve begins behind the bulbus, somewhere in the optic pathways, producing secondary degeneration along the optic nerve and the optic tract as far as, and including, the lateral geniculate body. Gudden's commissure (Moxter<sup>10</sup>), a structure which, according to modern anatomists, does not belong to the central optic system, has been noted to be intact; furthermore, the so-called residual bundle of the *bandelette* of Marie and Léri<sup>11</sup> (*faisceau résiduaire de la bandelette*), belonging to the optic tract, is not involved. The conclusion is to be drawn that the anatomic alteration is located within the diencephalon (or, better, in the posterior part of the diencephalon) and is primarily confined to a certain group of fibers of the

3 Benedikt, M. Wien med Presse **22** 1, 40, 101 and 135, 1881

4 Léri, A. Nouv iconog de la Salpêtrière **17** 304, 1904

5 Moeli, C. Arch f Psychiat **30** 907, 1898, cited by Wilson, K. Neurology, edited by A. N. Bruce, Baltimore, Williams & Wilkins Company, 1940, vol 1, p 484

6 Holden, T. Arch f Ophth **38** 110, 1899, cited by Wilson, S. A. K., in Neurology, edited by A. N. Bruce, Baltimore, Williams & Wilkins Company, 1940, vol 1, p 484

7 Stargardt, K. Arch f Psychiat **51** 711, 1913

8 Deutsch, H. Arb a d neurol Inst a d Wien Univ **31** 129, 1929

9 Hechst, B. Arch f Psychiat **95** 107, 1931

10 Moxter. Ztschr f klin Med **29** 334, 1896

11 Marie, P., and Léri, A. Rev neurol **13** 246, 1905

optic tract—in other words, it is a “systemic” alteration of nerve fibers within the optic tract, including certain components of the corpus geniculatum laterale. According to the literature and to personal clinical experience, the papillomacular bundle appears to be spared, or to be involved only in the later stages. There are several good reasons for believing that this bundle, arising from ganglion cells of the macula and the paramacula, represents in itself an entity, which primarily is not involved in the “tabetic” process. The nature of this “systemic” lesion is not clear. It may not be inflammatory, since, as has been mentioned, there is no evidence of degeneration of the ganglion cells of the retina. The cornea and the choroid likewise are not inflamed. The lesion is neither ascending nor exogenous (toxic). There are no signs of increased local pressure. One might compare this lesion to the systemic lesions observed in many congenital diseases of the spinal cord (such as Friedreich’s disease and amyotrophic lateral sclerosis) or to the spinal lesions of acquired and “inherited” tabes dorsalis. In tabes dorsalis only certain fibers of the posterior columns and, specifically, the central part of the posterior roots are affected, i. e., that part where the root, before entering the spinal columns, takes on a “central” character. The same selective alteration of certain fibers is the significant feature of tabetic atrophy of the optic nerve. It is probable, although it has not been conclusively proved, that this type of bilateral atrophy of the optic nerve (without neuritic signs) may occur not only in the tabes of adults and of children with congenital syphilis, but in another hereditary syphilitic condition of the spinal cord, namely, combined systemic degeneration.

The lesion under discussion is not “syphilitic” *sensu strictissimo*, since spirochetes have never been demonstrated within the optic nerve fibers. It is interesting, furthermore, that although in cases of dementia paralytica spirochetes are numerous in the brain, atrophy of the optic nerve is rare. Antisyphilitic treatment (both specific and nonspecific) does not exert any great influence on the course of atrophy of the optic nerve. The atrophy is progressive, even though the blood and spinal fluid have become serologically “negative.” In reviewing the clinical material in the General Hospital of Vienna from 1905 to 1925, John<sup>12</sup> found that despite the progress of antisyphilitic treatment the percentage of cases of tabetic atrophy of the optic nerve remained unchanged. This fact, together with the predominance in males, as shown by Oliver’s<sup>2</sup> statistics, and the rarity of atrophy of the optic nerve in dementia paralytica, as compared with its incidence, 15 per cent, in tabes would indicate that an endogenous factor may be decisive in the pathogenesis. I shall return to this point again.

12 John, I. Ztschr. f. Augenh. 69 283, 1929

The bilateral character of the lesion is certainly indicative of a central, and not a peripheral, origin. The systemic, noninflammatory, nontoxic, nonascending, central process may likewise lead one to suggest with due caution that its background is a congenital anomaly. The optic nerve not being a "peripheral" nerve, but in point of development and structure, a central nerve tract (fasciculus opticus), the concept of tabetic atrophy of the optic nerve as a systemic degeneration may meet with no great opposition. In view of the fact that in cases of *tabes dorsalis* the spinal cord exhibits infantile proportions and the arrangement of the spinal tracts is variable, often differing from the normal, regular, pattern (Stern<sup>13</sup>), it is fair to assume that an analogous irregularity in the structure of the optic nerve and optic tract may account for the variety of the visual defects associated with tabetic atrophy of the optic nerve. Because of this variability in visual disturbance, apparently, it has been found hard to correlate the anatomic and the clinical features.

Originally the lesion may be confined to a small part of the brain, i. e., the posterior section of the diencephalon, from which are derived not only the lateral geniculate bodies, but also the optic tracts and nerves, the neural part of the hypophysis and the epiphysis. The important vegetative center (Karplus and Kreidl<sup>14</sup>, Ranson<sup>15</sup>) is located not far away. The diencephalon is the area where the primary site of a certain type of primary atrophy of the optic nerve is assumed to exist (Hess<sup>16</sup>)—the type associated with adiposity and genital disorders. It has been pointed out, on the other hand, that normal physical growth is closely related to the activity of a normal brain and of a normal hypophysis and epiphysis (Hess<sup>16</sup>). The location of the congenital anomaly would lead one to expect some abnormality in the physical growth of persons with atrophy of the optic nerve. Syphilis is the precipitating, not the causative, agent. In support of this concept, it is essential to provide evidence, (a) that *tabes dorsalis* is not merely a disease of the spinal cord but may involve the diencephalon in a certain percentage of cases, as does Friedreich's disease (Hess<sup>16</sup>), and (b) that definite characteristics of body build and physical growth are clinically noticeable in tabetic persons with atrophy of the optic nerve, demonstrating an endogenous alteration of the diencephalic area.

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13 Stern, R. (a) *Archiv f. d. neurol. Inst. d. Wien Univ.* **14** 329, 1908, (b) *Ueber körperliche Kennzeichen der Disposition zur Tabes*, Leipzig, F. Deuticke, 1912.

14 Karplus, P., and Kreidl, A. *Archiv f. d. ges. Physiol.* **129** 138, 1909, **135** 401, 1910, **143** 119, 1911, **171** 192, 1918.

15 Ranson, S. W., in *Harvey Lectures*, Baltimore, Williams & Wilkins Company, 1936.

16 Hess, L. *Pathogenesis of Glaucoma and "Glaucomatous" Atrophy of the Optic Nerve*, *Arch. Ophth.* **37** 324 (March) 1947.

## DIENCEPHALIC SIGNS ASSOCIATED WITH TABES DORSALIS

Signs of diencephalic involvement associated with tabes dorsalis have been reported by many authors. Guillain<sup>17</sup> noted athetoid movements, clonism, tic and rhythmic tremor, confined particularly to the facial musculature and to the velum palatinum, and in other instances to the muscles of the fingers ("tabetic athetosis"). Schilder and Stengel<sup>18</sup> gave evidence of an anatomic lesion of the great basal ganglions in a case of tabes with severe ataxia and alteration of the *Stellfunktion*, without sensory defects in the arms but with slow athetoid movements of both legs. Dereux<sup>19</sup> expressed the belief that signs of derangement in function of the infundibulum—adiposity, loss of hair, sexual disorders and narcolepsy—may be encountered in tabetic patients. In line with this statement is the coincidental occurrence of tabes and lipomatosis (Weiss<sup>20</sup>), since in some cases of lipomatosis (Dercum<sup>21</sup> and many other authors) anatomic changes in the hypophysis, an important part of the hypothalamus, have been observed. More important, and, as will soon be seen, of fundamental significance, is Dercum's observation on a tabetic patient with signs of acromegaly, due to enlargement of the glandular part of the hypophysis, as proved by autopsy. It is recognized that acromegaly may not seldom be associated with tabes. Dercum reported sclerosis of the posterior columns in his case, Buday and Jancso<sup>22</sup> and Arnold<sup>23</sup> observed degeneration of Goll's column in cases of acromegaly, Tamburini<sup>24</sup> noted degeneration of Burdach's funiculus, and Bonardi,<sup>24</sup> degeneration of the posterior and lateral columns, in other cases of this disorder. The clinical course of the tabes in most of these cases was mild. Not only the full blown picture of tabes but the rudimentary signs, such as loss of the knee jerk, lightning pains and disturbances of the bladder, have been noticed in association with acromegaly ("pseudotabes pituitaria"). It is not impossible that in some of these cases the tabes was extremely mild or was early arrested. Not merely acromegaly, but occasionally another diencephalic disorder—underdevelopment of the pituitary body with dwarfism—is to be found combined with tabes dorsalis, the course of which, again, is mild, or even asymptomatic. In a case recorded and published by Katzenstein,<sup>25</sup> that of a woman aged 51, dwarfism, tabes with atrophy of the optic nerve and retinitis pigmentosa

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17 Guillain, G. *Neurol Centralbl* **47** 74, 1927

18 Schilder, P., and Stengel, E. *Ztschr f d ges Neurol u Psychiat* **113** 613, 1928

19 Dereux, I. *Neurol Centralbl*, 1902, p 404

20 Weiss, I. *Verhandl d deutsch Gesellsch f inn Med*, Feb 9, 1905

21 Dercum, F. *J Nerv & Ment Dis* **35** 507, 1908

22 Buday, K., and Jancso, N. *Deutsches Arch f klin Med* **60** 385, 1898

23 Arnold, T. *Virchows Arch f path Anat* **135** 1, 1894

24 Cited by Stern<sup>13b</sup>

25 Katzenstein, R. *Virchows Arch f path Anat* **289** 222, 1933



were present. Her height was 131 cm, her weight, 127.6 Kg, and the circumference of the skull, 50.5 cm. She had never menstruated. The labia majora were small and the labia minora hardly recognizable, the trunk and axillae were hairless, the nipples were undeveloped. The abdominal wall and the thighs were fat. The uterus and the clitoris were very small, the ovaries were the size of a half-bean, the hypophysis was the size of a lentil, the anterior lobe was almost entirely replaced by fibrous tissue. There was a gray degeneration of the posterior columns throughout the length of the spinal cord. Bilateral atrophy of the optic nerve and retinitis pigmentosa with progressive impairment of vision had been present since the thirtieth year. There was no ataxia of the hands. Romberg's sign was positive. Hammer toe was present bilaterally. The mother had had 16 children and 2 abortions. The case deserves attention because of the coincidence of atrophy of the optic nerve, genital disorders and adiposity, a syndrome to which attention has previously been directed (Hess<sup>16</sup>). The course of the tabes was mild, almost asymptomatic, with involvement of the pituitary body. The case reminds one of Benedikt's law and suggests that the unusually mild course of the disease in certain cases of tabes with atrophy of the optic nerve may be related to an alteration of the diencephalic-hypophysial system. Noteworthy is the fertility of the patient's mother. This is in line with Nettleship's<sup>26</sup> observations, he reported an average of 9 children to each family tainted with retinitis pigmentosa. The tabes dorsalis and the retinitis pigmentosa in Katzenstein's case were congenital. The same may be true, although it has not been proved, for atrophy of the optic nerve, or at least for the anlage. In a case of pituitary dwarfism with hypoplasia of both optic nerves reported by Kraus,<sup>27</sup> the syndrome of adiposity, genital disorders (hypoplasia of the external genital organs and cystic degeneration of both ovaries), malformation of the pituitary body and extensive alteration of the optic nerve could again be demonstrated.

From the clinical viewpoint, the loss of libido sexualis and voluptas in the early states of tabes dorsalis and the sterility of tabetic women (from 50 to 60 per cent are childless), on the one hand, and the satyriasis and priapism, occasionally lasting for weeks, on the other, point to a lesion of the diencephalon. According to my personal experience, an initial loss of weight represents a first sign of tabes. This "unexplained" loss of weight may be due to damage to the vegetative center. But there are also tabetic patients in good physical condition, with rosy cheeks and well developed panniculus adiposus—these are the patients with atrophy of the optic nerve!

26 Nettleship, J. Tr. Ophth. Soc. U. Kingdom 7: 301, 1887, 29: 128, 1909.

27 Kraus, E. I. Beitr. z. path. Anat. u. z. allg. Path. 65: 535, 1919.

In epidemic encephalitis, with its predilection for the mesencephalon and the diencephalon, tabetiform signs (loss of weight, the Argyll Robertson sign or absolute fixity of the pupils, abolition of the tendon reflexes, hypotonia of the muscles and a neuritic (?) lesion of the optic nerves) are well known. In this connection, the association of tabes with another organic disease of the mesencephalon and diencephalon—paralysis agitans—is noteworthy.

The conclusion seems justified that with tabes dorsalis anatomic or functional disorders of the diencephalon are not uncommon. A primary alteration of the hypophysis, evidenced by signs of acromegaly, may, on the other hand, occasionally present signs of mild, arrested tabes. The diencephalic disorder is acquired or congenital, but even when acquired may be connected with a certain disposition (anlage). This association of tabes and a diencephalic lesion appears to be the more probable as a certain body build is to be observed frequently in tabetic persons, to which attention will be directed in the following section. This body build points to an anomaly within the hypophysiodiencephalic system, and this defect is to be considered, in addition to syphilis, as an important factor in the pathogenesis of tabes in many instances.

While studying the vegetative nervous system, Eppinger and Hess<sup>28</sup> noted an exaggerated response to injection of pilocarpine in some tabetic patients. Others manifested spontaneous hyperhidrosis, sialorrhea, lacrimation, painful, watery diarrhea, bradypnea, or inhibition of respiration, and hypersecretion of the vulvar and vaginal mucosa (*crises clitoridiennes*). All these phenomena are in accord with the slowness with which atropine induces mydriasis, as noted in the introduction to the paper. It is of interest that the increased response to pilocarpine was observed chiefly in cases of tabes with amblyopia, demonstrating the imbalance of the vegetative sphere in this type of tabes.

#### BODY BUILD OF TABETIC PATIENTS

*Juvenile Tabes Dorsalis*—In the search for a body build characteristic of tabetic patients, the most impressive features were noticed in persons with juvenile tabes, i. e., the type with an inherited syphilitic background and developing in early adolescence (or even childhood), but most frequently at the age of puberty.

The patients, in addition to sometimes presenting signs of inherited syphilis, are thin, frail and considerably stunted in physical growth (Hough<sup>29</sup>). The proportions of the body in the adolescent tend to exhibit infantile characteristics. The gonads and mammary glands are underdeveloped. The menarche is delayed. Phimosis and cryptorchism may occur. In boys, the larynx is rather small and the voice high pitched.

28 Eppinger, H., and Hess, L. *Ztschr. f. klin. Med.* 68: 69, 1905.

29 Hough, W. H. *J. Nerv. & Ment. Dis.* 36: 577, 1909.

Secondary sexual signs are absent Grinker<sup>29a</sup> noted the feminine appearance of a male patient, Brissaud and Gy,<sup>29b</sup> masculine features in a girl Signs of rickets are conspicuous and frequent At autopsy (Middlemass<sup>21</sup>) the uterus and ovaries were observed to be of infantile size

It is tempting to trace both the physical and the sexual underdevelopment to one factor, a central hypophysiodiencephalic lesion In hereditary syphilis anatomic involvement of the pituitary body is well known In a series of 12 cases of this type of syphilis Simmonds<sup>30</sup> observed necrosis gummas and inflammatory changes of the hypophysis in no less than 50 per cent Hydrocephalus is not uncommon in syphilitic children and is apt to influence the function of the hypophysis and the vegetative center of the diencephalon

Both infantilism and dwarfism are known to occur in children with inherited syphilis (Nonne,<sup>31</sup> Rolleston<sup>31a</sup>) This infantilism may be associated with mental retardation, amenorrhea and absence of secondary sexual characters, with signs of diencephalic disturbance (polyuria, adiposogenital dystrophy) True acromegaly, however, has never been noted in cases of congenital syphilis, which, as a destructive process, does not add to the activity of the hypophysis In cases of tumors of the hypophysis without acromegaly, Hirsch<sup>32</sup> noted amenorrhea in 92.5 per cent of the women Of these cases of tumors of the hypophysis without acromegaly he found visual disturbances in 100 per cent and primary atrophy of the optic nerve in 89 per cent From the functional viewpoint this nonacromegalic, amenorrheic category of hypophysial growths is somewhat comparable to the hypophysial involvement occurring with congenital syphilis According to Erdheim,<sup>33</sup> the genital disorders as well as the adiposity associated with diseases of the hypophysis are dependent on the destruction within the hypophysiodiencephalic system The atrophy of the optic nerve and the destructive process within the diencephalon are, apparently, closely related

The clinical picture of tabes juvenilis presents remarkable features The course of the disease is mild, reminding one of Benedikt's law,<sup>3</sup> sometimes almost asymptomatic (except for the Argyll Robertson sign or the absence of tendon reflexes) Ataxia is of moderate degree although Romberg's sign is present Sphincteric disturbances of the

29a Grinker, J J Nerv & Ment Dis **31** 753, 1904

29b Brissaud and Gy Encephale **1** 172, 1909, Rev neurol **17** 16, 1909

30 Simmonds, M Dermat Wchnschr **58** 104, 1914

31 Nonne, M Syphilis and Nervensystem, Berlin, S Karger, 1924, p 931

31a Rolleston, H Thesis, London, 1921

32 Hirsch, O Wien klin Wchnschr **39** 93, 1926, Ztschr f Augenh **45** 294, 1921, Presse med **34** 578, 1926

33 Erdheim, J Beitr z path Anat u z allg Path **46** 233, 1909

rectum and the urinary bladder take a minor place. Lightning pains are not extremely severe. Mental development is retarded (Marburg<sup>34</sup>). There is no nystagmus, an important feature differentiating juvenile tabes from Friedreich's disease. The cranial nerves are not involved. So far as my limited personal experience shows, there are no signs of status dysraphicus (Bremer). Most impressive is the amazingly high incidence of primary atrophy of the optic nerve—40 per cent, according to Rosenheck. The pupils are rather large. No signs of keratitis or chorioretinitis are evident. The coincidence of primary bilateral atrophy of the optic nerve and "diencephalic" signs is noteworthy, in my opinion.

*Acquired Tabes Dorsalis*—Endogenous Factor. The spinal cords of tabetic patients have been noted to present dystopias of the fibers and infantile proportions (Stern<sup>13a</sup>). Atrophy of the gonads was observed by Bitot and Sabrazès,<sup>35</sup> Rivière<sup>36</sup> and Fournier<sup>37</sup>. The origin of this atrophy is not clear. Should it prove to be congenital, it would be comparable to the atrophy of the testes associated with hypophysiodiencephalic disorders (Berblinger,<sup>38</sup> Kraus<sup>39</sup>).

According to the statistical studies of Mattauschek and Pilcz,<sup>40</sup> of 4,134 syphilitic officers of the Austrian army, dementia paralytica developed later in 4.79 per cent and tabes dorsalis in only 2.73 per cent. This remarkable observation suggests that, in addition to the precipitating infectious agent, an endogenous anomaly is requisite to the development of tabes. The rather high incidence of diabetes mellitus in the families of tabetic patients (Strohmayer<sup>41</sup>) is noteworthy. In families in which there appeared a certain type of tabes with adiposity, which was often associated with bilateral atrophy of the optic nerve, Stern<sup>13b</sup> observed adiposity and diabetes mellitus. The association of tabes or of tabetiform signs with endocrine disorders—acromegaly, as has previously been mentioned, exophthalmic goiter and Addison's disease—is interesting, since in all these conditions the presence of a lesion of the hypophysis cannot be doubted (acromegaly, with its well known anatomic background, exophthalmic goiter, in which Osler<sup>42</sup> suggested that the

34 Marburg, O. *Wien klin Wchnschr* **19** 1295, 1906.

35 Bitot, E., and Sabrazès, J. *Rev de méd. Paris* **11** 897, 1891.

36 Rivière, G. *De l'anesthésie et de l'atrophie testiculaires dans l'ataxie locomotrice progressive*, Bordeaux, 1885.

37 Fournier, A. *Leçons sur la période préataxique*, Paris, 1885.

38 Berblinger, W. *Beitr z path Anat u z allg Path* **89** 233, 1931.

39 Kraus, E. J. *The Hypophysis*, in Henke, F., and Lubarsch, O. *Handbuch der speziellen pathologischen Anatomie und Histologie*, Berlin, Julius Springer, 1926, vol 8, p 810.

40 Mattauschek, E., and Pilcz, A. *Ztschr f Neurol u Psychiat* **8** 138, 1912.

41 Strohmayer, W. *Neurol Centralbl* **26**.755, 1907, cited by Stern,<sup>13b</sup> p 71.

42 Osler, W. *Principles and Practice of Medicine*, edited by H. A. Christian, ed 14, New York, D. Appleton-Century Company, Inc., 1942, p 1168.

hypophysis played a primary role, and Addison's disease, with involvement of the adrenal gland and, besides, a distinct decrease of basophilic cells in the pituitary body, according to Crooke and Russell<sup>43</sup>) As for diabetes, Houssay's diabetogenic factor in the anterior lobe of the pituitary gland should be recalled Dufour and Cottenot<sup>44</sup> and Thies<sup>45</sup> reported impairment in the condition of tabetic women during pregnancy, another indication of a possible role of the endocrine glands, particularly the hypophysis, in the course of tabes

As for the visual disturbances associated with atrophy of the optic nerve in tabes, it was mentioned in the introduction to this paper that the visual fields for red and, particularly, for green may be contracted early in the course of tabes, whereas appreciation for blue remains intact for a longer period This earlier loss of the fields for red and green would mean a defect of that part of Hering's *Schsubstanz* which represents the physical substratum for red and green sensation At present there is no means of knowing whether this defect is acquired or congenital Establishment of its congenital origin would provide a link with color blindness (protoanopia and deuteranopia)

According to modern physiology, dark adaptation is largely dependent on the activity of the rods (Kries<sup>46</sup>) Consequently, the early impairment of dark adaptation in cases of tabes with atrophy of the optic nerve suggests an anomaly of the rods Embryologically, the rods, derivatives of the outer neuroblastic layer of the bulbus, and the hypophysis make their appearance at about the same time, in the eleventh or twelfth week of embryonic life, and it is possible that a congenital structural or functional anomaly of the rods may be linked with the disturbances of the pituitary body<sup>47</sup> On the other hand, it has been demonstrated that in this early stage of embryonic life the roof of the hypophysial pouch lies immediately on the diencephalon and so is intimately connected with the optic nerve (Hochstetter<sup>48</sup>)

**Conclusion** I conclude that there exists a definite predisposing abnormality in patients with acquired tabes dorsalis and that there is evidence that the site of this anomaly is the hypophysiodiencephalic area

**Body Build** From Stern's<sup>13b</sup> extensive clinical studies, ample evidence has been accumulated that Stiller's "asthenic" body build

43 Crooke and Russell, cited by Muir, R Textbook of Pathology, ed 5, Baltimore, Williams & Wilkins Company, 1941, p 959

44 Dufour, H, and Cottenot, M Bull et mem Soc med d hôp de Paris 27 211, 1909

45 Thies, J Charité-Ann 34 591, 1910

46 Kries, J Klin Monatsbl f Augenh 70 577, 1923

47 The function of the rods is believed to be connected with vitamin A metabolism

48 Hochstetter, F Beiträge zur Entwicklungsgeschichte des Menschlichen, Vienna, F Deuticke, 1924, vol 2, p 2

(leptosomatic," according to Kretschmer<sup>49</sup>, "linear," according to Stockard) represents an important factor in the genesis of acquired tabes. Dementia paralytica appears to be related, rather, to the "muscular," or "lateral," type. In a series of 122 patients reported by Stern, 76 were of the "asthenic" type and 46 of the "muscular" type. Of the 76 asthenic patients, 65 had tabes, 3 dementia paralytica and 8 questionable dementia paralytica, but of the 46 patients of the "muscular" type, 22 had tabes, 14 dementia paralytica and 10 questionable dementia paralytica. This agrees with Chaillou's<sup>50</sup> observation that his patients with dementia paralytica had an usually well developed musculature (*type musculaire*). Signs of rickets are of frequent occurrence in tabetic patients. According to my personal experience, rickets is often to be found in asthenic patients. In a family of several children who were infected with syphilis in early childhood, Stiefler<sup>51</sup> noted that only the 2 asthenic members acquired tabes, the others being spared. On close examination, the asthenic body build may exhibit variations, as will be seen later. Stiefler's classic picture, however, has many features in common with that of castrated persons described by Tandler and Grosz<sup>52</sup>: the long, thin extremities, weak musculature, lack of muscular tone, and underdevelopment of the external sexual organs and of the secondary sexual characters. The common denominator of the two conditions may be found in a disorder of the endocrine glands, dependent in the asthenic patients on the hypophysiodiencephalic system.

Although a profound metabolic disorder and, consequently, considerable loss of weight are initial signs in a majority of cases of tabes, it is essential to make one comment.

In certain cases of tabes with rapid loss of weight (tabes marantica) one is reminded of the extreme emaciation and cachexia of Simmonds' disease, due to atrophy of the anterior lobe of the hypophysis. The syndrome of loss of weight, asthenia, amenorrhea, sterility and loss of sexual power and desire encountered in Simmonds' disease are similar to the signs and symptoms of this type of tabes dorsalis. In contrast to this type, there is a form of tabes in which the patient is comparatively well nourished and rather obese. It is in cases of this type that primary atrophy of the optic nerve is likely to develop. The course of this type of tabes is rather mild. The clinical contrast between the two categories is striking. It suggests a corresponding contrast in the makeup of the endocrine glands, notably, in the activity of the pituitary system. Certain

49 Kretschmer, E. *Körperbau und Charakter*, Berlin, Julius Springer, 1936, p. 21.

50 Chaillou, A. *Clinique* 6:305, 1911.

51 Stiefler, G. *Wien klin Wchnschr* 22:163, 1909.

52 Tandler, J., and Grosz, S. *Arch f Entwicklungsmechn d Organ* 27:21, 1909, 30:236, 1910.

structural variants of the physique may substantiate this hypothesis. In view of these indubitable facts, one is tempted to search for a relation between atrophy of the optic nerve and this category of *tabes dorsalis*. Does there exist a link between primary atrophy of the optic nerve and the type of physique of certain tabetic patients?

In the second and third articles in this series,<sup>53</sup> moreover, attention was called to the diencephalon and its vegetative center, on the one hand, and the production of glaucomatous attacks, on the other. Since in certain cases of glaucoma atrophy of the optic nerve may develop, the cause of which is unknown, does a link exist between this "glaucomatous" atrophy and the structural pattern?

The records of the following 8 cases may serve as an illustration of my point of view and as an answer to this question.<sup>54</sup>

**CASE 1**—T. H., a man aged 72, the second of 11 children, had a history of measles, malaria, gonorrhea and syphilis thirty years before. The patient neglected his treatment for syphilis, he was given a few injections. There was no history of "crises" or of ataxia or incontinence. He complained of headache and impaired eyesight.

*Examination*—There were dulness from the apex of the lung to the level of the first dorsal segment on the right side and sensitivity of the right brachial plexus on pressure. The breath sounds were diminished over the area of dulness. The larynx deviated to the right. The boundaries of the heart were normal, the second aortic sound was accentuated. The blood pressure was 185 systolic and 105 diastolic. Both the temporal and the radial arteries were thick and tortuous. Pulsation of the brachial arteries was visible on both sides. The malleoli, the capitulum of the ulnas, both clavicles, the parietal bones and Ludwig's angle were thick. The pupils were equal, centrally located and pinpoint in size. The Argyll Robertson sign was present, the patellar reflexes were weak, particularly on the right side. The ankle reflex was weak on both sides. Romberg's sign was not elicited. In 1929 the Wassermann test gave a positive reaction in all dilutions. After lumbar puncture the patient had a severe headache. The cell count of the spinal fluid was 87 per cubic millimeter. The colloidal gold curve was 1233210000 (1930). After tryparsamide therapy the serologic reactions of the blood and the spinal fluid were negative.

The patient was rather tall (height, 174 cm) and lean (weight, 164 pounds [74.4 Kg]), the circumference of the chest was 84.2 cm. The chest was long, flat and hairless, the abdomen was flat, with a circumference of 74.5 cm. There was a marked median furrow, starting close to the epigastric angle and extending down to the umbilicus. The skull was high, suggesting oxycephaly. The circumference of the skull was 56 cm and the height 13.6. The zygomas were prominent, the chin was strong and large, with a median groove, both rami of the mandible were strong. The frontal sinuses and the glabella were prominent. The occiput was bulging. The tongue was thick and deviated slightly to the right. The teeth were large and strong. The scrotum and penis were large.

<sup>53</sup> Hess, L. Pathogenesis of Acute Glaucoma, *Arch. Ophth.* **32** 128 (Aug) 1944, Pathogenesis of Glaucoma, *ibid.* **33** 392 (May) 1945.

<sup>54</sup> The ophthalmologic data were furnished by Dr. Henry Boruchoff and Dr. Albert Elsberg, of the Beth Israel Hospital, Boston.

The feet were flat and strikingly long (the tip of the heel to the tip of the right toe was 25 cm) The thighs and legs were thin, both hands were thin and long (length of the right index finger, 10 cm, length of the right middle finger, 11.3 cm)

Ophthalmic examination showed glaucomatous atrophy with characteristic cupping of the disk and opacities in the lens of the left eye The anterior chambers of the eyes were shallow Ocular pressure was high in each eye, with a tension of 35 to 50 mm (Schiotz) in the right eye and of 40 to 100 mm in the left eye Vision was 20/40 in the right eye and questionable in the left eye No essential changes were apparent in the fundus of the right eye

*Summary*—This case was characterized by late syphilis, hypertension, a healed (tuberculous?) lesion in the apex of the right lung, mild tabes, an asthenic habitus with acromegaloid signs, unilateral atrophy of the optic nerve and glaucoma simplex

Remarkable in this case was the fertility of the patient's mother The patient himself had no children I wish to stress this high degree of fertility in the family, which has not been noted in the literature It has been noted earlier in this paper in connection with tabes juvenilis It holds true also of juvenile dementia paralytica Of 8 cases of the latter disease described by Nonne,<sup>31</sup> a high degree of fertility was evident in 6 (Nonne paid no attention to this fact) According to Nettleship,<sup>24</sup> the families of patients with retinitis pigmentosa are unusually prolific In my personal experience, this feature is not uncommon in families of feebleminded and degenerate children whom I had the opportunity to study in the Wrentham State School

The body build of the patient is the classic "habitus asthenicus" Acromegalic traits, nevertheless, are noticeable (large chin and zygomas, pronounced frontal sinuses and glabella, strong lower jaw, large genitalia) Some of these signs may be related to rickets The predisposition of asthenic patients to rickets has been mentioned

Furthermore, the high skull seems to be noteworthy, reminding one of oxycephaly In the fourth article,<sup>16</sup> the coincidence of oxycephaly and atrophy of the optic nerve was discussed, and the height of the skull was traced back to an abnormality of the middle fossa, with probable involvement of the diencephalon Interestingly, in Kraus's<sup>27</sup> case of nanosoma pituitaria associated with congenital hypoplasia of the optic nerves the skull was surprisingly high (index, [height/length] 76.6) and pointed In nanosoma pituitaria without atrophy of the optic nerve the skull is short, brachycephalic or hyperbrachycephalic, but not high This fact should be borne in mind

I have noticed the long hands and feet (cheiromegaly and podomegaly) in a great many children with disproportionate growth

The tabes in this case was mild, almost asymptomatic

The diagnosis of "glaucoma simplex" was established on the basis of the principal signs, there were no signs of acute congestion The



unilateral atrophy of the optic nerve was undoubted. Its relation to tabes cannot be ruled out, as the atrophy of the fellow nerve may occasionally develop several months or years later.

CASE 2—G S, a housewife, aged 52, the second of 8 children, had had measles and whooping cough during childhood. In 1917 she had a "genital sore," which was "irregularly" treated with injections. The menarche occurred at the age of 11, the menses were regular and painful. The menopause occurred at the age of 46, without difficulty. She was delivered of 1 child, who died at the age of 6 weeks.

*Examination*—Examination revealed dulness of the apex of both lungs, with dilated superficial Kuty veins in this area and diminished breath sounds. There were dilated subcutaneous veins on the anterior aspect of the chest and cor pendulum. The heart tones were of good quality, the blood pressure was 145 systolic and 70 diastolic. Both pupils were small, the left one was spherical and the right one irregular in shape, both were fixed to light but reacted to distance. The abdominal reflexes were normal on the left side, those on the right were absent (postoperative scar). The knee and ankle reflexes were normal, the Romberg sign was not elicited. There was a zone of hypalgesia below the right breast. Lumbar puncture, performed with the patient in the reclining position, revealed an initial pressure of 80 mm, after removal of 10 cc of fluid the pressure was 25 mm. The total proteins measured 50 mg per hundred cubic centimeters. The reaction for globulin was negative. The Wassermann-Hinton reaction of the fluid was negative. The cell count revealed 1 cell per cubic millimeter. The patient was black haired, tall (height, 170 cm), slender (weight, 98 pounds [44.5 Kg]), never exceeding 128 pounds [58.1 Kg]) and leptosomatic (chest flat, axillary and genital hair and eyebrows scanty), with prominent acromegaloid signs (large, plump fingers and toes, heavy, high chin, large mandibular ramus, large upper incisors, widely separated, large tongue, with a median and a pronounced lateral fissure), and high forehead.

The left eye showed deep glaucomatous cupping of the optic nerve head and atrophy of the nerve. There was complete absence of vessels temporally. Both anterior chambers were shallow. The patient experienced no pain in the eye.

Tension was 35 mm (Schiotz) in the right eye and 90 mm in the left eye. Vision was 20/20 in the right eye and doubtful in the left eye.

*Summary*—There were fibrotic changes in the apexes of both lungs, mild tabes, an asthenic habitus with acromegaloid features, glaucoma simplex and unilateral atrophy of the optic nerve.

Remarkable in this case are the fertility of the patient's mother (the patient herself had only 1 child) and the mild course of the tabes. The glaucoma was almost painless, as are many conditions (childbirth, pneumonia) in cases of tabes.

CASE 3—A K, a Russian Jew aged 56, was the fifth of 11 children. His father, one of 17 children, died at the age of 83, of old age. His mother died at the age of 84, of heart disease. There was a past history of tonsillectomy, chronic suppurative otitis media with perilabyrinthitis and syphilis (1918), which was treated with arsphenamine, tryparsamide and a preparation of mercury. The patient did not drink or smoke. He complained of dizziness, headache, sleeplessness and blurred vision.

*Examination*—There were slight cyanosis of the lips. Dulness was noted on the right side from the apex of the lung down to the second dorsal segment, with slight atrophy of the right trapezius and supraspinatus muscles and bronchial breathing over that area. The trachea and larynx were displaced to the right side. The boundaries of the heart were found on percussion to be the right sternal border, the third rib and the left midclavicular line. Fluoroscopic examination revealed a distance from the midline of 4.8 cm to the right border and of 9.8 cm to the left border and a transverse diameter of 14.6 cm (enlargement of the left ventricle). A soft systolic murmur was heard over the entire precordium. The second aortic sound was not accentuated. An electrocardiogram showed left axis deviation and a prolonged P-R interval (myocardial damage). The edge of the liver was about 2 fingerbreadths below the costal margin. The spleen was not enlarged. The blood pressure was variable, at times being 190 systolic and 120 diastolic and at others 220 systolic and 120 diastolic. Nodal piles were present. The pupils were equal and narrow, with a bilateral Argyll Robertson sign. The patellar reflex was diminished on both sides. The Achilles reflex was more active on the right side than on the left. All abdominal reflexes were missing except in the left upper quadrant. The Romberg sign was not elicited. The Wassermann reaction of the spinal fluid was positive in 1919 and later became negative.

The patient was of medium size (height, 167 cm) and obese (weight, 162 pounds [73.5 Kg]). The cheeks and nose were reddish, the nose was snub, and the forehead was large but not high. The neck was short and thick. The shoulders were rounded, with a pronounced deltoid-pectoral furrow. The chest was large and deep—almost barrel shaped. The hands were soft, short and broad. The legs were rather thin. The pelvis was large and of feminine type. There were deposits of fat on the lower part of the abdominal wall and on the thighs. A deep furrow was present above each knee. Gynecomastia was present. Both testes were small and soft, he had had no erection for ten years. The pubic hair was of horizontal outline, but a few hairs were present along the linea alba. The back and chest were hairless except for a few short hairs toward the lower part of the sternum. There were few hairs on the anterior aspect of the lower part of the legs. The eyebrows were scanty, particularly laterally. The skull was large, with a circumference of 57.3 cm and a sagittal diameter of 18.9 cm. The bifrontal diameter was 15.8 cm, the cephalic index, 84.6. The palate was large and the chin heavy.

Tension was 43 to 45 mm (Schiotz) in the right eye and 55 to 75 mm in the left eye, vision was 10/20 in the right eye and consisted of light perception with projection temporally and below in the left eye. There was bilateral atrophy of the optic nerve with glaucomatous cupping. Degenerative patches were present in the retina of the left eye. Both anterior chambers were shallow.

*Summary*—The case was characterized by late syphilis, slowly progressive nephrosclerosis with myocardial damage, fibrotic changes in the apex of the right lung, hemorrhoids, chronic otitis media, mild tabes, pyknic habitus with genital disturbance, bilateral atrophy of the optic nerve and glaucoma (diagnosed many years ago).

Noteworthy are the longevity of the patient's family, the mild course of the tabes, the classic pyknic habitus combined with genital disorders (soft testes, impotency, gynecomastia, female type of pelvis, feminine distribution of pubic hair, scanty hair on the body) and acromegaloid signs (strong chin, large tongue, scanty eyebrows).

It seemed of interest to describe briefly these 3 cases representing the association of glaucoma simplex with mild tabes. The glaucoma was practically painless. In 2 cases the asthenic type of body build was combined with acromegaloïd signs, in the third case the pyknic habitus, which is rare in tabetic patients, was combined with genital disorders.

Three cases of glaucoma not complicated with tabes may be summarized from the standpoint of constitutional type.

CASE 4—N. S., a Negro, aged 52, had a history of gonorrhea in 1908 and of syphilis in 1918. The syphilis had been treated with a bismuth compound. His wife had had 3 or 4 miscarriages. The patient had always been strong and able to lift heavy weights. The muscles of his arms and legs were unusually strong and of athletic volume. The testes and the scrotum, however, were small, the skin of the latter being soft, thin and unwrinkled. The pubic hair was horizontal in outline and scanty. The chest, abdominal wall, axillae and both arms were hairless, but a few hairs were noted near the lateral aspect of the upper and lower portions of the legs. The chin was heavy and large. The zygomas and the glabella were large.

There were no clinical signs of neurosyphilis. The Wassermann-Hinton and Kahn reactions of the blood were negative.

Tension was 32 mm (Schiotz) in the right eye and 27 mm in the left eye. Vision was 20/50 in the right eye and 20/30 in the left eye. The optic disk of the right eye was atrophic and pale, with a deep excavation near the margin of the disk. A surgical coloboma marked the site of an operation performed several years ago because of an acute attack of pain. The disk of the left eye was normal.

*Summary*—The case was one of late syphilis and glaucoma with unilateral atrophy of the optic nerve.

Kretschmer<sup>40</sup> expressed the belief that the combination of "dysgenitalism" and the athletic body build is not uncommon. It certainly indicates an abnormal development due to a diencephalic factor. Cases of glaucoma have been recorded in the literature in which antisyphilitic treatment was to some extent successful. I venture to surmise that these old cases may have been instances of arrested or mild neurosyphilis associated with glaucoma.

CASE 5—L. M., a housewife aged 67, had had the menarche at 17 ("was given medicine for it") and the menopause at 47. The menstrual periods were always irregular and painful. She had had 3 miscarriages and 4 deliveries.

The patient was of the adipose-pyknic type, with deposits of fat on the thighs and the abdominal wall, the arms and chest being spared. The mammary glands were poorly developed (she had been unable to nurse any of her children). Her weight was 177 pounds (80.3 Kg), and her height, 169 cm, her face was "pentagonal." There were no signs of old rickets.

Tension was 32 mm (Schiotz) in the right eye and 40 mm in the left eye. Vision was 20/30 in the right eye and 20/30 in the left eye.

No nasal contraction of the visual fields was noted. There were pronounced cupping and atrophy of both nerve heads.

*Summary*—The patient was of adipose-pyknic type with "dysgenitalism." She presented glaucoma with bilateral atrophy of the optic nerve and moderately increased

ocular pressure at the time of the examination (The patient showed a certain tendency to "fertility")

CASE 6—S C, a man aged 70, was a Russian Jew, the youngest of 6 siblings. His father died at the age of 75, he had had trouble with his feet (semile gangrene?), his mother died at about the same age, of an unknown disease. The patient was married and had 7 children, 1 child was born blind and "without a brain", 1 son was stated to be an inmate of a state hospital for a disease believed to be incurable (dementia precox?) The patient could not control his bladder until the age of 6 (nocturnal enuresis?) He had typhoid at 16 and an attack of "rheumatic fever" at 20, with no recurrence. In recent weeks he had experienced a sensation of pressure on the chest after excitement or on climbing stairs. The pain was controlled by glyceryl trinitrate. The patient had been a heavy smoker for years. There was no history of alcoholic abuse or of venereal disease. He had always been stout and fat, his weight ranging from 200 to 205 pounds (90.7 to 93 Kg), he had lost about 5 pounds (2.3 Kg) in recent weeks. Bowel movements and appetite were normal.

*Physical Examination*—When the patient was first seen, his weight was 198 pounds (89.8 Kg), and his height, 5 feet 7½ inches (171.5 cm). There was no cyanosis or peripheral edema, the veins of the neck were not distended. Both radial arteries were thin, the pulse was slightly irregular, the blood pressure was 140 systolic and 70 diastolic. The boundaries of the heart were the third rib, the right sternal border and the left midclavicular line. The heart beat was not palpable, the sounds were of good quality but distant. There was immobility of the base of the left lung with small dilated veins over this area (Sahl's wreath). The urine was normal, the Wassermann-Hinton reaction of the blood was negative, the electrocardiogram showed premature auricular beats, a rate of 65 per minute, left axis deviation, an inverted T wave in lead III and a normal lead IV.

The patient was stout and rather obese, with deposits of fat on the lower part of the abdominal wall and a deep transverse fold above the symphysis. Fat was abundant on both thighs, with less on the upper parts of the arms. The chin was double, the neck was short and large. The nasolabial folds were deep. The nose was rather thick, the nostrils were wide, the tip of the nose and the cheeks were reddened. The skull was large and of mesaticephalic type. The measurements were as follows: bitemporal diameter, 14.0 cm, bimaxillary diameter, 10.0 cm, sagittal diameter, 18.5 cm, height, 21.5 cm. The cephalic index was 75.6. The circumference was 57.3 cm. The vertex was flat and the occiput moderately bulging. The face was broad, the mandibles were slightly curved, with a moderate amount of fat on the lateral portions. The lateral contour of the face was almost vertical. The palate was large. The pubic hair was horizontal, with only a few hairs along the linea alba. A group of dark hairs was confined to the sacral area. The axillae and the four extremities were hairless. (The beard had never been strong.) The testes were small and soft (due to age?). The prostate was not enlarged. There were no definite signs of rickets. The chest was large and short, suggesting the "barrel chest," with wide, symmetric costal angles. The tip of the spleen was palpable. The liver was not enlarged. The deep, cutaneous and right pupillary reflexes were normal.

*Ophthalmic Examination*<sup>55</sup>—In January 1940 the patient stated that for about a year he had had attacks of blurring at night, which cleared up in the morning. Two

<sup>55</sup> The ophthalmologic data were furnished by Dr Benjamin Sachs, of the Beth Israel Hospital, Boston.

weeks prior to examination he had considerable pain and blurring in the left eye. Examination revealed severe congestive glaucoma in the left eye, with considerable steaminess of the cornea and practically no anterior chamber. The pupil of this eye was widely dilated. Tension was 66 mm (Schiotz). Vision consisted only of light perception. The right eye had normal tension but a very shallow anterior chamber. Mecholyl and neostigmine were administered to the left eye, with little influence on the pressure. A paracentesis was performed. The miotics had no effect on the tension. An iridectomy was done. Tension was controlled, and vision improved. By May the tension was within normal limits. Both anterior chambers were very shallow. The left iris was atrophic. The right optic disk was normal. The left optic nerve was atrophic. Vision was 20/40 in the right eye with glass (high hyperopia with hyperopic astigmatism) and 20/50 in the left eye.

*Summary*—The patient was of pyknic type with "dysgenitalism," unilateral "glaucomatous" atrophy of the optic nerve, healed pleurisy of the left side and hypertrophy of the left ventricle.

The following 2 cases of mild tabes may serve to illustrate both the pyknic-dysgenital and the asthenic-acromegaloid category of the disease. Neither patient had glaucoma.

CASE 7—S I, a Portuguese aged 40, complained chiefly of blurred vision in both eyes, of about nine months' duration. There was no history of syphilis. The Wassermann-Hinton tests of the blood and the spinal fluid, however, gave positive reactions.

Both pupils were miotic and fixed to light, with a normal reaction in accommodation. Both the ankle and the knee jerks were absent. The Romberg sign was not elicited. The cremasteric and abdominal reflexes were hyperactive. There was no mental deterioration.

The patient was well nourished (with no notable loss of weight in recent months). The skull was rather high and of hypsicephalic type (bregma-chin measurement, 138 cm). There were a double chin and deposits of fat on the abdominal wall, the thighs and buttocks. The chin was short and large, with two pads of fat. The bridge of the nose was sunken. The glabella was rather large and prominent. The legs and fingers were thin and delicate, the latter being long and hyperextensible. The thorax was short and large and covered with hair. The testes were small and soft and were not sensitive to pressure. The pelvis was large, of feminine type. No sign of rickets was apparent. Atrophy of the optic nerve was present bilaterally, with both fields contracted peripherally. The ocular pressure was normal. Vision was 20/30 in each eye.

*Summary*—The patient had tabes dorsalis, oligosymptomatic (with no history of "crises" and no pronounced ataxia), and bilateral primary atrophy of the optic nerve. He was of pyknic habitus with a tendency to female adiposity and a certain degree of dysgenitalism. He had no history of initial loss of weight.

CASE 8—A man aged 74, a painter, had been troubled for four or five years with sharp pains in the left leg, of sudden onset and short duration. The eyesight had begun to fail. The bowels were regular. The bladder was continent. Bilateral herniorrhaphy had been performed five years before. He had 5 children, all of whom were reported to give negative serologic reactions of the blood.

The pupils were unequal and of irregular size, reacting sluggishly to light and better in accommodation. The mobility of the eyeballs was not restricted. There

was no nystagmus. The knee and ankle reflexes were absent. The Romberg sign was not elicited. The patient walked with a broad base. There were no prominent sensory defects. The Hinton reactions of the blood and spinal fluid were negative. The reaction of the fluid for globulin was positive. The cell count was 198 per cubic millimeter. The colloidal gold curve was 5544321100. The total protein was 62 mg per hundred cubic centimeters. Both disks were pale, they presented no inflammatory changes. Both fields were contracted peripherally. Ocular pressure and the anterior chambers were normal.

The patient was tall (height, 5 feet 6 inches [167.5 cm]), lean (weight, 147 pounds [66.7 Kg]) and pale. He was euphoric. The skull was of hypsicephalic type. The chest was long and flat, with an acute epigastric angle. The tenth rib fluctuated on each side. Moderate deposits of fat were present on the upper portions of both arms (of feminine distribution) and on the abdominal wall. The trunk and all the extremities were hairless. The chin was large and high, with two grooves. The fingers and toes were large and plump. The nose was large. The pubic hair was scanty.

*Summary*—The patient presented tabes dorsalis, oligosymptomatic, bilateral atrophy of the optic nerve, acromegaloid signs, and a tendency to the feminine type of obesity. There were undoubtedly signs of asthenic habitus. The flat, long chest with the acute epigastric angle, the fluctuating ribs, the tendency to herniation (frequent, in my personal experience, with the asthenic habitus) and the scanty pubic hair (which had always been so) were evidence. But at first glance the picture of "asthenia" might be obscured by the acromegaloid signs (large chin, large toes and fingers, large nose) and the tendency to adiposity. These transitional forms are theoretically important, as they are indicative of a participation of the hypophysiodiencephalic system.

#### COMMENT

The rare occurrence of tabes in syphilitic patients (in about 2 per cent) compares well with the infrequency of nervous complications following certain other infectious diseases (diphtheria, influenza, malaria) or toxic conditions (alcoholism). It demonstrates that an endogenous factor is decisive in the pathogenesis of certain anatomic diseases of the central nervous system.

As for the endogenous agent operative in acquired tabes dorsalis, Stiller's habitus asthenicus deserves attention, because in a majority of tabetic persons objective clinical signs or subjective symptoms (weakness, fatigue, vague pains) of this type of organization can be observed. There are indications that in the asthenic type the hypophysiodiencephalic system is involved, at least so far as sexual disturbances, physical underdevelopment and a tendency to association with hypophysial disorders are concerned. In certain cases of tabes unquestionable signs of diencephalic origin can be detected. Of the cases of acquired tabes there is a small number, about 15 per cent, associated with primary atrophy of the optic nerve, whereas in cases of juvenile (congenital) tabes this proportion is much higher (40 per cent, or even 60 per cent according to some authors).

It is known that in cases of congenital syphilis the pituitary body frequently shows anatomic alteration. This change, together with the stunted growth and sexual retardation, may be considered evidence of a congenital anomaly of the hypophysiodiencephalic area. It leads one to compare the rather frequent occurrence of atrophy of the optic nerve in cases of juvenile syphilis with the frequent occurrence of optic atrophy with certain nonacromegalic tumors of the pituitary body. There might be a link between primary atrophy of the optic nerve and dys-pituitarism in cases of juvenile tabes.

The mild course of juvenile tabes is similar to the well known mild course in the cases of acquired tabes with associated bilateral atrophy of the optic nerve. The mild, amaurotic form of acquired tabes presents either the asthenic habitus combined with acromegaloid features<sup>56</sup> or the pyknic habitus combined with signs of adiposogenital dystrophy.<sup>57</sup> The body build is the *conditio sine qua non* for the development of atrophy of the optic nerve.

Both the acromegaloid signs and the signs of adiposogenital disturbance being correlated with a change in the diencephalon, the atrophy of the optic nerve associated with acquired tabes may have the same pathogenesis as the atrophy occurring with juvenile tabes.

The diencephalic lesion under discussion is essentially a minute congenital anomaly of the brain. On the basis of this anomaly, the atrophy of the optic nerve is later precipitated by syphilis. This congenital lesion may provide a clue to the understanding of some clinical peculiarities of atrophy associated with tabes (early impairment of dark adaptation, a possible link with color blindness, or daltonism).

Atrophy of the optic nerve associated with tabes is not analogous to degeneration of the posterior roots, as has been assumed by many authors. With pernicious anemia at least, in which degeneration of the posterior roots and spinal column is frequent (in about 60 per cent of cases according to Hurst), atrophy of the optic nerve is rare. Apparently, in pernicious anemia the important hypophysiodiencephalic factor is missing.

Tabetic atrophy of the optic nerve is combined neither with nystagmus nor with cataract. As was pointed out, there are no signs of mechanical pressure on the optic nerves, nor are there any signs of inflammation.

Tabetic atrophy of the optic nerve is to be considered a systemic degeneration within the central optic pathways, between the bulbus and the primary optic centers of the brain. From the clinical standpoint, it may be compared to a certain category of primary atrophies of the optic

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56 Uhthoff<sup>1</sup> Oliver<sup>2</sup> Deutsch<sup>8</sup>

57 Benedikt<sup>3</sup> Stargardt<sup>7</sup>

nerve characterized by coincidence of the atrophy with diencephalic signs and a congenital anomaly within the middle fossa (Hess<sup>10</sup>)

As regards the nature of this lesion, the possibility of a trophic disturbance should be borne in mind. In the light of modern research (Warkany<sup>11</sup> and his co-workers) there appears to exist a connection between congenital malformations and nutritional disturbances.

The coincidence of "mild" tabes and glaucoma is not without interest. In some sense, it may corroborate the hypothesis that the main clinical signs of glaucoma are dependent on involvement of the diencephalon (Hess). The body build of patients with glaucoma and atrophy of the optic nerve is the same as the body build of patients with tabes complicated with amaurosis.

The body build, if early recognized and evaluated, would provide an indication to the further course of the disease. How far the management of the condition may be influenced by this concept will be discussed in the next paper. Although the significance of mechanical pressure in the pathogenesis of "glaucomatous" atrophy of the optic nerve cannot be neglected, the diencephalic factor deserves further study.

Like the primary atrophy of the optic nerve encountered with certain diseases of the middle fossa (oxycephaly, hypertelorism, certain tumors of the pituitary gland, Friedreich's disease, arachnoiditis interchiasmatica, retinitis pigmentosa, arachnodactyly and infantile myxedema) and with pregnancy, and like the atrophy of the optic nerve in certain cases of tabes dorsalis, "glaucomatous" atrophy of the optic nerve may be connected with a congenital anomaly of the diencephalic area. The site of the glaucomatous attack and that of the congenital anomaly would be located in the close neighborhood of the vegetative center of the diencephalon. It is well to remind oneself that the optic nerve is connected with many parts of the diencephalon (nucleus supraopticus and tuber cinereum) by anatomically well defined tracts (tractus retinosupraopticus and the medial and lateral tractus retinotuberales) serving the transmission of impulses directly from the retina to the pituitary system.

#### GENERAL CONCLUSIONS

Two features are prominent in glaucoma: increased intraocular pressure and atrophy of the optic nerve. The pain, although important, remains in some cases more or less in the background.

The intraocular pressure depends mainly on a neural regulation initiated by means of reflexes. The receptor organ of this reflex action is the ciliary ganglion. This is the only sensory center for all stimuli arising within the bulb.

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58 Warkany, J. Congenital Malformations Induced in Rats by Maternal Nutritional Deficiency, *Am J Dis Child* 65:882 (June) 1943.



Glaucoma is essentially a neuroregulatory disturbance. It either starts suddenly, like a "crisis," or develops insidiously. Glaucoma is always "secondary."

The eyeball is a viscus and is "represented," as are all visceral organs, in the diencephalon. This "vegetative" center is subject to influences from the cortex (anxiety, nervous strain). In any case of glaucoma the primary site is thought to be in one of the following structures: (1) the peripheral nerve terminals within the bulbus, (2) the ciliary ganglion, (3) the diencephalon or (4) the cortex.

The therapy, if rational and, in compliance with the requirements in different cases, is to be directed to the terminal nerves, to the diencephalon or to the cortex. (The terminal nerves and the ciliary organ represent one unit.) Miotics act on the terminal nerves.

Atrophy of the optic nerve complicating glaucoma is associated with increased intraocular pressure. Aside from the pressure mechanism, there exists in certain cases of glaucoma a definite tendency to atrophy of the optic nerve. This tendency depends on a congenital anomaly, and the pressure mechanism in these cases acts as a precipitating factor.

This "glaucomatous" atrophy of the optic nerve bears a similarity to the atrophy associated with certain organic diseases of the brain. The latter type of atrophy is based on a structural anomaly of the skull (middle fossa) and of the brain (diencephalon).

Atrophy of the optic nerve is prone to develop either in persons with asthenia associated with acromegaloid features or in those with a pyknic body build associated with signs of adiposogenital disturbance. Early study of many cases from the neurologic-constitutional standpoint will assist in making the prognosis and possibly in preventing atrophy of the optic nerve.

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# GONORRHEAL IRITIS

Experimental Production in the Rabbit

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AND

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## GONORRHEAL IRITIS IN MAN

THE RECOGNITION of gonorrheal iritis has been delayed by several factors. First, Hunter's classic self inoculation resulted in gonorrhea and syphilis being considered for decades as manifestations of a single disease. Second, the association of iritis with arthritis of various kinds, including the gonorrheal, served to complicate matters. Third, gonorrheal iritis tended to be mistaken for the more commonly encountered purulent gonorrheal conjunctivitis, from which it had to be distinguished.

The clinical picture of gonorrheal iritis slowly emerged from the case reports and studies of Brodie,<sup>1</sup> Vetch,<sup>2</sup> Travers,<sup>3</sup> Frick,<sup>4</sup> Lawrence,<sup>5</sup> Mackenzie,<sup>6</sup> de Wecker,<sup>7</sup> Forster,<sup>8</sup> Fournier and Galezowski,<sup>9</sup> Hutchin-

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2 Vetch, J. A Practical Treatise on the Diseases of the Eye, London, G. Whittaker and W. B. Whittaker, 1820, pp. 243-246.

3 Travers, B. A Synopsis of the Diseases of the Eye, ed. 2, London, Longman, Hurst, Rees, Orme and Brown, 1821, p. 129.

4 Frick, G. A Treatise on the Diseases of the Eye, Baltimore, Fielding Lucas Jr., 1823, p. 42.

5 Lawrence, W. A Treatise on the Diseases of the Eye, London, John Churchill, 1833, pp. 233-237, Washington, D. C., Duff Green, 1834, pp. 186-189, ed. 4, edited by I. Hayes, Philadelphia, Blanchard & Lea, 1854, pp. 309-312 and 347.

6 Mackenzie, W. A Practical Treatise on the Diseases of the Eye, London, Longman, Rees, Orme, Brown and Green, 1830, pp. 376-381, Boston, Carter, Hendee & Company, 1833, pp. 312-316, ed. 4, Philadelphia, Blanchard & Lea, 1855, pp. 534-537.

*(Footnotes continued on next page)*

son,<sup>10</sup> Griffith,<sup>11</sup> Lawford and others,<sup>12</sup> Beaumont,<sup>13</sup> Cobbledick<sup>14</sup> and many others

Proof of the gonorrheal origin of the iritis was slow in forthcoming. Of necessity, it had to wait on the discovery by Neisser<sup>15</sup> in 1879 of the gonococcus and its subsequent growth in culture by Bumm<sup>16</sup>

In 1897 Karsnitski<sup>17</sup> published the detailed report of a case of gonorrheal iritis appearing a month after the onset of acute gonorrheal urethritis and a week after its subsidence. Examination of pus obtained by paracentesis from the anterior chamber revealed intracellular gonococci "identical with those of the previously examined urethral pus." In 1911 Sidler-Huguenin<sup>18</sup> reported the results of blood cultures and cultures of material from the anterior chamber of 5 patients with gonorrheal iridocyclitis. The blood cultures of 3 of the patients were positive, and material obtained from the anterior chamber of 1 of them yielded a pure culture of gonococci. The author concluded that the ocular complication was hematogenous. All 5 patients also showed optic neuritis.

Byers, in 1907, published a comprehensive monograph,<sup>19</sup> which is probably the best work on the ocular metastasis of gonorrhea. In it

7 de Wecker, L., in Graefe, A., and Saemisch, T. *Handbuch der gesamten Augenheilkunde*, Leipzig, Wilhelm Engelmann, 1874, vol 4, pt 1, pp 497-498

8 Forster, in Graefe, A., and Saemisch, T. *Handbuch der gesamten Augenheilkunde*, Leipzig, Wilhelm Engelmann, 1877, vol 7, pt 5, pp 86-87

9 Fournier and Galezowski, cited by Byers<sup>19</sup>

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15 Neisser, A. Ueber eine der Gonorrhoe eigentumliche Micrococcusform, *Centralbl f d med Wissensch* 17 497-500, 1879

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17 Karsnitski, A. V. A Case of Gonorrheal Iritis, *Voyenno M J (med-spec pt)* 190 824-829, 1897

18 Sidler-Huguenin. Ueber metastatische Augenentzündungen namentlich bei Gonorrhoe, *Arch f Augenh* 69 346-378, 1911

19 Byers, W. G. M. A Study of the Ocular Manifestations of Systemic Gonorrhoea with Reports of Cases of This Nature, *Stud Roy Victoria Hosp* 2 107-231, 1908. Dr Byers furnished us with a copy of his monograph and granted us permission to reproduce an illustration (fig 1, p 163) from it

he reported the first histologic study of a case of gonorrheal iritis. Since this monograph is not easily available, the illustration is reproduced (fig 1). The patient was a young man with gonorrhea, polyarthritis and septic fever. Six weeks after the onset of the disease his left eye was the site of mild but well defined iritis. The eye was recovering satisfactorily under treatment when obscure gastrointestinal symptoms set in and the patient died; the cause of death was acute dilatation of the stomach. Histologic examination of the eyeball showed keratic precipitates on the posterior surface of the cornea, swelling and small round cell infiltration of the iris, swelling and dense cellular invasion of the ciliary body and a rather massive fibromucellular exudate along the whole

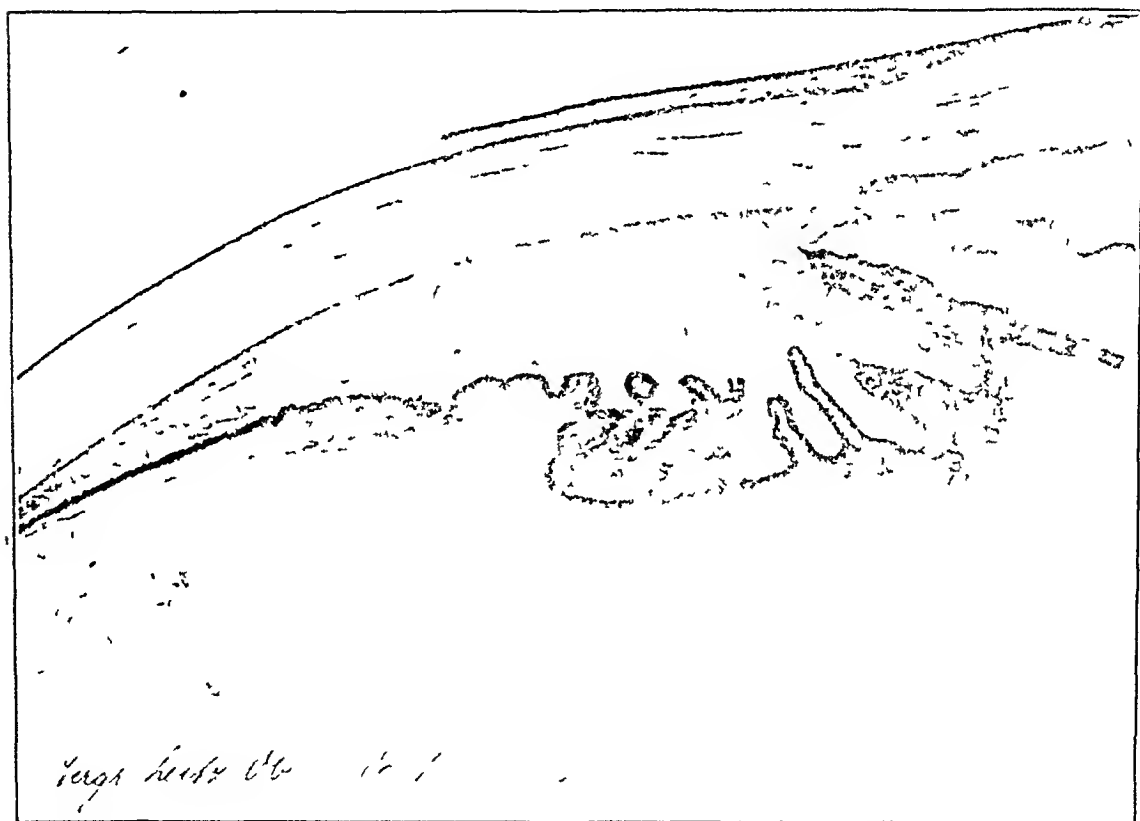


Fig 1—Microscopic section from Byers,<sup>10</sup> case of gonorrheal iridocyclitis

extent of the ciliary processes. A differential count of the cells in the exudate showed that small mononuclear cells predominated over polymorphonuclear forms. Careful search with various stains for gonococci and other possible organisms gave negative results. Particularly striking were the degree and extent of anatomic involvement, in contrast with the mild gross clinical findings.

Roosa,<sup>20</sup> in 1906, reported a case of "gonorrheal metastatic iridocyclitis," although the evidence for its gonorrheal origin was inadequate.

<sup>20</sup> Roosa, D. B. St. J. A Case of Metastatic Gonorrheal Choroiditis. Enucleation of the Eye, Post Graduate **21**: 692-693, 1906.

Similarly, in Kravitz<sup>21</sup> case of gonorrheal endophthalmitis following cataract extraction the diagnosis was made merely on the presence of intracellular and extracellular diplococci, identified by the pathologist as gonococci, in the conjunctival smear

Velhagen,<sup>22</sup> in 1937, published the report of a case of iridocyclitis in which histologic study of the enucleated bulb revealed organisms which he considered to be gonococci. The tenability of this conclusion is open to question, since it was based solely on the intraocular presence of gram-negative diplococci, and no gonococci or other evidence of gonorrhea was ever observed elsewhere in the patient. Velhagen did not consider the meningococcus as a possible etiologic agent. It is an organism almost identical morphologically with the gonococcus, and meningococcus carriers are not uncommon in healthy population groups.<sup>23</sup> Granted Velhagen's assumption of a gonococcic origin, the histologic observations were interesting. The capsule of the lens was broken on its anterior aspect, and the anterior chamber was filled with innumerable pus cells and swollen lens fibers, among which clumps of the microorganisms were visible. The iris was greatly edematous and hyperemic, the ciliary body was infiltrated with pus, and the posterior portion of the lens was embedded in a purulent mass containing numerous colonies of bacteria. The iris and the ciliary body contained no organisms. The posterior segment was only slightly involved.

In addition to the cases of optic neuritis associated with gonorrheal iritis cited by Byers<sup>19</sup> and Sidler-Huguennin,<sup>18</sup> additional cases were reported by Krause,<sup>24</sup> Cobbledick<sup>25</sup> and von Hippel.<sup>26</sup> The last-mentioned author expressed the belief that the optic neuritis was the chemotactic effect of a toxin diffusing backward from the inflamed anterior segment. Byers also collected 6 cases of optic neuritis in which there was no apparent associated iritis.

As encountered clinically, gonorrheal iritis manifests no especially diagnostic characteristics. It occurs much more commonly in males than in females. It generally does not arise until a few weeks after the initial genitourinary infection, and then often in association with other

21 Kravitz, D. Postoperative Endogenous Infections of the Eye, *Am J Ophth* **19** 328-330, 1936

22 Velhagen, C. Eitrige Iridocyclitis mit Gonokokken in Augennern, *Klin Monatsbl f Augenh* **98** 20-23, 1937

23 Miller, C. P., Beadenkopf, W. G., Peck, D., and Robbins, M. W. A Survey of Chronic Meningococcus Carriers in a Semi-Permanent Population, *J Infect Dis* **74** 212-224, 1944

24 Krause, P. Zwei Falle von Gonokokkensepsis mit Nachweis der Gonokokken im Blute bei Lebzeiten der Patienten, *Berl klin Wchnschr* **41** 492-494, 1904

25 Cobbledick, A. S. Gonorrhoeal Iritis Complicated by Interstitial Optic Neuritis, *Ophthalmoscope* **10** 319-320, 1912

26 von Hippel, E. Ueber einen Fall von ungewohnlich schwerer gonorrhoeischer Iridocyclitis und Neuritis optica, *Arch f Ophth* **94** 355-360, 1917

evidences of systemic spread (arthritis, septicemia, endocarditis, or subcutaneous abscesses) Some urologists have noted so close a correlation between the onset of the iritis and instrumentation or massage that 1 of them<sup>27</sup> has even recommended chemotherapy during these procedures<sup>28</sup> Indeed, the diastic manipulative therapy of gonorrhea in males, in contrast with the more conservative treatment of the disease in females, may account for the greater incidence of iritis (and other metastatic complications) in the male

The classic ocular picture is that of severe anterior uveitis, with grayish, gelatinous exudate virtually filling the anterior chamber, sometimes with hypopyon and at other times with hyphema After a few weeks the process subsides and recovery is complete, often without a single synechia Another type of gonorrheal iritis is said to be characterized by the formation of extensive posterior synechias, multiple recurrences and eventual atrophy Also attributed to gonorrhea is a simple, mild iritis in which complete recovery generally occurs whether or not treatment of any sort is instituted How large a proportion of the cases of "one day iritis" fall into this category is a matter for speculation, since a thorough investigation is not usually made and the subject does not appear to have been of sufficient importance to have warranted much study

Among reports in the literature of this century, Collins and Silcock<sup>29</sup> stated that gonorrhea was the causative factor in 15 per cent of 100 cases of iritis, Yeld,<sup>12</sup> in 8 per cent of 159 cases, Chevallereau and Chaillous,<sup>30</sup> in 7 per cent of 131 cases, Gutmann,<sup>31</sup> in 3 per cent of 150 cases, Straub,<sup>32</sup> in 3 per cent of 161 cases, Goulden,<sup>33</sup> in 11 per cent of 179 cases, Irons and Brown,<sup>34</sup> in 5 per cent of 200 cases, Bulson,<sup>35</sup> in

27 Herrold, R D Chemotherapy of Gonococcic Infections, St Louis, C V Mosby Company, 1943, p 76

28 Among others, Ward (*Brit M J* **1** 755-758, 1901), Hamilton,<sup>12</sup> Browning (*Brit J Ophth* **4** 102-106, 1920) and Holloway (*Am J Ophth* **14** 232-238, 1931) have pointed out the association of traumatic therapy and the origin or exacerbation of systemic gonorrheal processes

29 Collins, and Silcock, in discussion on Griffith<sup>11</sup>

30 Chevallereau, A, and Chaillous, J Recherches sur l'etiologie de l'iritis, *Compt rend Cong internat (Lucerne)*, 1904, pp 310-313

31 Gutmann, A Beitrag zur Aetiologie und Statistik der primären Iritis, *Deutsche med Wchnsch* **31** 1671-1673, 1905

32 Straub, M Ueber Hyalitis und Cyclitis, *Arch f Ophth* **86**:1-68, 1913

33 Goulden, C Inflammation of the Uveal Tract Secondary to Infection of Mucous Membranes, *Roy London Ophth Hosp Rep* **19** 328-375, 1914

34 Irons, E E, and Brown, E V L The Etiology of Iritis, *J A M A* **81** 1771-1776 (Nov 24) 1923

35 Bulson, A E The Etiology and Treatment of Endogenous Iritis An Analysis of One Hundred Consecutive Cases in Private Practice, *Tr Am Ophth Soc* **23** 292-327, 1925

5 per cent of 100 cases, Gilbert,<sup>36</sup> in 3 per cent of 500 cases, Gifford,<sup>37</sup> in 7 per cent of 118 cases, and Zeeman,<sup>38</sup> in 12 per cent of 290 cases

In a series of 562 patients with uveitis, Guyton and Woods<sup>39</sup> expressed the belief that gonorrhea was the definite etiologic factor in 18 per cent and the presumptive etiologic factor in an additional 28 per cent. While admitting that the criteria for the gonorrheal origin of a particular case of uveitis were open to criticism and left doubt as to the accuracy of the diagnosis, they stated that the "complement fixation test is of principal value in ruling out the possibility of gonorrhea as a cause of uveitis."

In this connection, it might be well to heed the warning of some acknowledged experts in the general field of gonorrhea. Van Slyke, Thayer and Mahoney<sup>40</sup> stated "There is a distinct tendency to ascribe to laboratory findings a degree of infallibility which may exceed the limitations of the procedure employed." Their findings are worth summarizing. Cultures and duplicate smears were made of the cervical secretion of 664 female patients. One hundred and forty of the cultures were found to yield gonococci, the identity of the organisms being confirmed in all instances by appropriate sugar fermentation reactions. The smears for these 140 patients were examined by three competent microscopists and reported to show gonococci in 88, 47 and 40 instances, respectively. The smears for the 524 patients with negative cultures for gonococci were reported by the same three microscopists to contain the organisms in 76, 13 and 4 instances, respectively.

With such inconsistency in the bacteriologic diagnosis of an easily accessible genital type of gonococcic infection, it is no wonder that a positive diagnosis of intraocular gonorrhea can so rarely be established.

The gonococcus complement fixation test has been disappointing as a diagnostic procedure. As a result of several studies, its validity has been seriously questioned. Gohring,<sup>41</sup> for example, in a comparative series of complement fixation tests made on 300 patients with gonorrhea, found positive reactions in 42 and 51 per cent, respectively, when two different gonococcus antigens were used and in 40 per cent when a

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36 Gilbert, W., in Schieck, F., and Bruckner, W. *Kurzes Handbuch der Ophthalmologie*, Berlin, Julius Springer, 1930, vol. 5, p. 3.

37 Gifford, S. R. A Review of the Literature on the Etiology of Acute Iritis, *Am J Ophth* **14** 100-110, 1931.

38 Zeeman, W. P. C., in Berens, C. *The Eye and Its Diseases*, Philadelphia, W. B. Saunders Company, 1936, p. 634.

39 Guyton, J. S., and Woods, A. C. Etiology of Uveitis. A Clinical Study of Five Hundred and Sixty-Two Cases, *Arch Ophth* **26** 983-1018 (Dec.) 1941.

40 Van Slyke, C. J., Thayer, J. D., and Mahoney, J. F. Comparison of Media and Laboratory Results in Gonococcus Cultures, *Am J Syph, Gonorr & Ven Dis* **26** 55-62, 1942.

41 Gohring, G. Experimentelle Untersuchungen zur Komplementbindungsreaktion bei Gonorrhoe, *Dermat. Wchnschr* **111** 625-628, 1940.

staphylococcus antigen was used. He also found a change in the reactions of the gonococcus complement fixation test in human subjects from negative to positive on the intravenous injection of suspensions of killed meningococci or staphylococci in increasing doses. In a recent critical review, Thomas<sup>42</sup> concluded that the complement fixation test for gonorrhea was not sufficiently accurate to have gained wide acceptance.

The application of sulfonamide compounds and of penicillin to the therapy of gonorrhea has in general constituted a great step forward. However, sulfonamide-resistant gonorrhea has become common, and more recently it has been demonstrated that the gonococcus may become resistant to penicillin.<sup>43</sup> The problem of gonorrhea is by no means completely overcome.

#### REVIEW OF THE LITERATURE ON EXPERIMENTAL GONORRHEAL IRITIS

The gonococcus has been a notably difficult organism to study in experimental infection. In an extensive survey of the literature from 1786 to 1943, Hill<sup>44</sup> was able to report little in the way of positive results. In the 234 papers she reviewed, no experiments were successful which utilized genitourinary tissue, rectal mucosa, nasal mucosa, pleura, joints, skin and subcutaneous tissues, the central nervous system, or the circulatory system as sites of the infection. A generalized sepsis has been produced in mice by means of peritoneal injection,<sup>45</sup> but this does not meet the needs of problems which require a localized infection for their investigation.

In a large number of the studies reviewed by Hill, ocular tissues were utilized. An occasional observer reported the presence of gonococci after conjunctival inoculation, particularly after sensitizing the tissue with bile, but the results all too often could not be confirmed or were marred by the presence of secondary contaminants. Corneal and subconjunctival inoculation gave similarly disappointing results.

Risso,<sup>46</sup> in 1892, on the injection of a suspension of organisms into the anterior chamber of the guinea pig, noted clouding of the aqueous after twenty-four hours and was able to see intracellular diplococci in the fluid.

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42 Thomas, R. B. The Gonococcus and Gonococcal Infections, *Am J Syph, Gonor & Ven Dis* **26** 691-774, 1942.

43 Bahn, J. M., Ackerman, H., and Carpenter, C. M. Development in Vitro of Penicillin-Resistant Strains of the Gonococcus, *Proc Soc Exper Biol & Med* **58** 21-24, 1945. Miller, C. P., and Bohnhoff, M. Studies on the Action of Penicillin IV. Development of Penicillin Resistance by Gonococcus, *ibid* **60** 354-356, 1945.

44 Hill, J. H. Experimental Infection with *Neisseria Gonorrhoeae*. II. Animal Inoculations, *Am J Syph, Gonor & Ven Dis* **28** 334-378 and 471-510, 1944.

45 Miller, C. P., and Hawk, W. D. Experimental Gonococcal Infection, *Tr A Am Physicians* **55** 216-218, 1940.

46 Risso, A. Colture del gonococco a scopo clinico, *Riforma med* **8**:507-509, 1892.



Steinschneider,<sup>47</sup> in 1893, noted that the injection of gonococci together with the medium (serum agar) into the anterior chamber of the rabbit was followed by the appearance of conjunctival hyperemia, clouding of the cornea, grayish white exudate in the anterior chamber and hypopyon. Both cultures and smears consistently failed to show gonococci. When either the gonococci or the medium alone was injected, no inflammatory reaction occurred.

De Christmas,<sup>48</sup> in 1897, reported the recovery of gonococci from the anterior chamber of the rabbit for twenty-four to forty-eight hours after inoculation. He defined the nature of the problem by stating that the gonococcus was not destroyed by the animal, "but dies principally because it does not find in the milieu of the living (laboratory) animal the conditions necessary for its survival. It is not known of what the particular conditions consist, or the specific properties of human mucosa which constitute so propitious an environment for this microbe, but the environmental differences must be important, since it appears thus far impossible to adapt the gonococcus to a new milieu."

Pompeani,<sup>49</sup> working in de Christmas' laboratory, inoculated the anterior chamber of rabbits with a bacteriologically sterile, alcohol-precipitated gonococcus toxin and noted a severe inflammatory reaction, manifested by chemosis, corneal opacification and vascularization, and hypopyon. He considered that this result demonstrated the remarkable pyogenic properties of the toxin. Intracorneal introduction of the toxin elicited the same results, as did injection of living gonococci. He also claimed to have produced a serum which was able to neutralize to a great extent the pyogenic action of the toxin.

Da Fonseca,<sup>50</sup> in 1898, inoculated the anterior chamber of the rabbit and observed some corneal opacification, hypopyon, anterior and posterior synechias and pupillary membranes. The inflammatory response diminished at the end of a week. Microscopic studies showed active phagocytosis, to which he ascribed the absence of gonococci in cultures of material obtained by the second day.

Scholtz<sup>51</sup> inoculated the anterior chamber of the rabbit with small numbers of living or killed gonococci and observed diffuse suppuration in the anterior chamber and clouding of the iris within a few hours. The

47 Steinschneider. Ueber die Cultur der Gonokokken, Berl klin Wchnschr **30** 728-731, 1893.

48 de Christmas, J. Contribution a l'etude du gonocoque et de sa toxine, Ann l'Inst Pasteur **11** 609-639, 1897.

49 Pompeani, F. Toxine et antitoxine du gonocoque, Thesis, Paris, no 170, Guerin, Derenne et Cie, 1898.

50 da Fonseca, A. R. Contribuição para o estudo do gonococco, Coimbra med **18** 324-327, 384-387, 393-395 and 414-416, 1898.

51 Scholtz, W. Beiträge zur Biologie des Gonococcus (Cultur, Thierexperimente und klinische Beobachtungen über gonococcenhaltige Abscesse im Bindegewebe), Arch f Dermat u Syph **49** 3-28, 1899.

pus was always sterile. He concluded that the inflammatory response was chemotoxic in origin.

Maslovski,<sup>52</sup> in 1899, injected three day serum broth cultures into the anterior chamber of 10 rabbits and obtained identical results in all the animals. At the end of one day there was diffuse corneal opacification and pus was beginning to accumulate in the anterior chamber. The pus contained polymorphonuclear leukocytes without gonococci. Numerous colonies of gonococci were obtained on culture after twenty-four hours, fewer after forty-eight hours and none on the third day.

Cantani,<sup>53</sup> in 1899, reported conjunctival and corneal inflammation, regressing after four days, on intraocular inoculation of a rabbit with gonococci. Culture of the mucopurulent secretion from the conjunctiva yielded no organisms.

Bruck,<sup>54</sup> in 1909, cited work performed with Meirowski in which gonococci were injected into the anterior chamber of the rabbit. Living gonococci were recovered after forty-eight hours, but not after seventy-two hours, when the inflammation subsided and absorption and organization of the exudate commenced. He expressed the belief that the process was not at all specific for the gonococcus.

Debré and Paraf,<sup>55</sup> in 1913, aspirated aqueous from the anterior chamber of the rabbit and then injected a suspension of gonococci containing approximately 200,000,000 to 300,000,000 organisms. A severe purulent panophthalmitis developed, progressing in some instances to corneal perforation. It resolved in about a month and was followed by atrophy of the bulb. No microscopic or cultural studies were made.

Mezincescu and Holban,<sup>56</sup> in 1919, following up the work of Debré and Paraf, were unable to find or to culture organisms. Since they were able to elicit similar suppuration on the inoculation of killed gonococci, they concluded that the reaction was a purely toxic one and that the gonococcus was not pathogenic for laboratory animals.

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52 Maslovski, V. I. Le rôle de la toxine du gonocoque dans les infections gonorrhéiques des organes génitaux internes de la femme, *Ann de gynéc et d'obst* **52** 574-588, 1899.

53 Cantani, A. Contributo allo studio del gonococco, *Riforma med* **15** 808-810, 819-821 and 831-833, 1899.

54 Bruck, C. Ueber spezifische Behandlung gonorrhöischer Prozesse, *Deutsche med Wchnschr* **35** 470-474, 1909.

55 Debré, R., and Paraf, J. Bases expérimentales de la sérothérapie antigonococcique. I. Ophthalmie expérimentale du lapin, son traitement par un sérum spécifique, *Compt rend Soc de biol* **75** 512-514, 1913, *Principes généraux et bases expérimentales de la sérothérapie antigonococcique*, *Presse méd* **21** 1013-1015, 1913.

56 Mezincescu, D., and Holban, D. Sur l'ophtalmie expérimentale à gonocoque chez le lapin, *Comp rend Soc de biol* **82** 536-537, 1919.

Terrien, Debre and Paraf,<sup>57</sup> in 1920, reported on further work done by their group, describing the ophthalmia in greater detail, together with histologic studies. The usual result of inoculating the anterior chamber of the rabbit with gonococci was a torpid iridocyclitis, evolving in ten to fifteen days, with moderate pericorneal injection, a large amount of exudate in the anterior chamber, synechias and abundant pus in the anterior chamber, terminating in total occlusion of the pupil and partial clouding of the cornea. In a few cases the involvement was less severe, with slight pericorneal injection, few synechias and little or no hypopyon. In other cases the involvement was graver, with severe pericorneal reaction, a much larger accumulation of pus in the chamber, glaucoma and sometimes corneal perforation and phthisis. They produced drawings of the histologic changes in the involved eyes but said nothing about searching for gonococci, either in the sections or by cultural methods. They merely cited Morax to the effect that gonococci did not grow in the observed lesions, apparently referring to the paper by Morax and Elmassian,<sup>58</sup> in which the statement was made that gonococci did not grow in or on animal conjunctivas on inoculation of the living microorganisms.

Cohn,<sup>59</sup> in 1931, made the most noteworthy recent contribution. He injected a turbid suspension of gonococci in isotonic solution of sodium chloride or Ringer's solution into the anterior chamber of the rabbit. He likened the clinical appearance of the eyes to that of similarly affected human eyes, with conjunctivitis, pericorneal injection, corneal opacification, and exudate and pus in the anterior chamber. These changes were present in one or another combination after twenty-four hours, became more intense during the following days and remained unchanged thereafter for three to four weeks. Cohn utilized twelve strains and a mixture of strains of the gonococcus in a total of 54 experiments. Material for culture was obtained by aspiration of the aqueous. Of the 54 cultures, the gonococcus was found in 21 between the fourth and twenty-eighth day. Some strains in particular yielded positive cultures in a significantly greater proportion of inoculations than did others. He concluded:

The injection of gonococci in the anterior chamber of the rabbit causes local clinical signs, but the viability of the infecting agent in the individual animal is variable and irregular. It is, nevertheless, noteworthy that in 2 instances gonococci were still culturally demonstrable after thirteen and twenty-eight days, respectively.

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57 Terrien, F., Debré, R., and Paraf, J. *Etude expérimentale sur la sérothérapie antigonococcique, symptômes et lésions de l'iridochoroïdite gonococcique*, Arch. d'opht. **37** 326-343, 1920.

58 Morax, M., and Elmassian, M. *Du rôle des toxines dans la production des inflammations de la conjonctive*, Ann. d'ocul. **122** 81-113, 1899.

59 Cohn, A. *Verimpfung von Gonokokken auf Kaninchen*, Dermat. Ztschr. **60** 35-41, 1931.

This is something never previously observed in any animal experiment. All in all, it remains questionable whether the anterior chamber of the rabbit is suitable for experimental induction of gonorrhea.

Balsamelli<sup>60</sup> utilized the technic of Terrien, Debré and Paraf in studies on the effect of various gonococcic antiviruses. He noted the development of panophthalmitis and obtained gonococci in pure culture from such inoculated eyes; he concluded, therefore, that the gonococcus was pathogenic for the rabbit.

#### EXPERIMENTAL PROCEDURE AND RESULTS

The work to be described here was originally initiated at the request of the Subcommittee on Venereal Diseases of the National Research Council as part of a comprehensive investigation into the whole problem of the chemoprophylaxis of venereal diseases. Its object was the development of methods for the testing of gonococcidal agents *in vivo*, which made it necessary to find a means of producing a localized gonococcic infection experimentally in some suitable laboratory animal.

These studies promised to yield results which bore not only on their primary objective but also on some of the many unsolved problems associated with uveitis. Preliminary<sup>61</sup> and final<sup>62</sup> reports on the study as a whole have already been published, to these the reader is referred for such details of technic as are beyond the scope of this paper, as well as immunologic, prophylactic and therapeutic observations.

The rabbits were healthy, young adults. Albinos were preferred, but it was not always possible to obtain them in sufficient numbers. Two strains of gonococci were used. One was derived from the blood culture of a patient with bacterial endocarditis, the other was from a patient with gonorrheal urethritis which had been resistant to sulfathiazole therapy. The medium used was a casein-digest cystine agar, usually enriched with 10 per cent fresh defibrinated rabbit blood. The cultures were incubated in a candle jar.

The rabbits were anesthetized with morphine or "demerol hydrochloride" (meperidine hydrochloride) intravenously and solution of cocaine or tetracaine topically. The hair around the eyes was clipped, and the lids were held apart with a speculum. Two-tenths cubic centimeter of aqueous was aspirated from

60 Balsamelli, F. Ricerche sperimentali sull'azione degli antivirus specifici ed aspecifici sul gonococco, Boll d Ist sieroterap milanese **13** 420-426, 1934, Propriete immunizzanti e terapeutiche degli antivirus specifici ed aspecifici nell'ipopion gonococcico sperimentale del coniglio, *ibid* **14** 232-236, 1935.

61 Miller, C. P., Moeller, V., and Bohnhoff, M. A Method for Production of a Localized Gonococcal Infection in the Rabbit's Eye, *Proc Soc Exper Biol & Med* **58** 143-146, 1945.

62 (a) Miller, C. P., Drell, M. J., Moeller, V., and Bohnhoff, M. Experimental Gonococcal Infection of the Rabbit's Eye. I. Method of Production, *J Infect Dis* **77** 193-200, 1945. (b) Drell, M. J., Miller, C. P., Bohnhoff, M., and Moeller, V. Experimental Gonococcal Infection of the Rabbit's Eye. II. Course of the Disease and Its Pathology, *ibid* **77** 201-215, 1945. (c) Miller, C. P., Bohnhoff, M., and Moeller, V. Experimental Gonococcal Infection of the Rabbit's Eye. III. Treatment with Prophylactic and Therapeutic Agents, *ibid* **77** 216-223, 1945.

the anterior chamber by means of a 25 or 26 gage hypodermic needle fitted to a tuberculin syringe. With a second syringe and needle, 0.2 cc of a suspension of gonococci in saline solution was then injected through the same needle track into the anterior chamber.

During the procedure the anterior chamber was emptied, and in many instances the hypodermic needle was observed to have inflicted trauma on the iris or the lens or both. Accordingly, in later phases of the investigation, a single syringe-puncture technique was used. The needle attached to a syringe containing the suspension of gonococci was introduced through the cornea into the anterior chamber. By repeated partial aspirations and injections a thorough mixture of the suspension of gonococci and the aqueous was effected, the anterior chamber contents at no time being more than half evacuated. The chamber was then completely filled and the needle withdrawn. The heat of summer was found to reduce the percentage of infections induced, and so the animals were kept in a room artificially chilled to a temperature of 50 to 60 F.

The eyes were examined grossly and studied with an ophthalmoscope and a hand slit lamp at daily to weekly intervals. The tension was estimated by touch and with a Soutter tonometer. Aqueous was withdrawn for culture, after anesthesia, with a syringe and hypodermic needle. At the end of the period of observation, the animals were killed by induction of air embolism. The bulbs were enucleated. Then either the several parts of the eyes were dissected under sterile conditions and streaked out on a culture plate or the bulbs were fixed in "Zenker-formol" (Zenker's fluid made up with solution of formaldehyde U.S.P.), embedded in paraffin, sectioned and stained with hematoxylin-eosin-azure II stain. In one series, an iridectomy was performed at the time of enucleation, the excised iris tissue cultured, and the rest of the bulb sectioned; this method yielded no gonococci in cultures, although the organisms could at times be identified in the sections. Attempts were made to preserve the morphologic character of the gonococci in the histologic sections by fixation with solid carbon dioxide immediately after enucleation; this was unsatisfactory. Some sections were stained with a modified Gram stain; this, too, was unsatisfactory.

Cultures from different parts of an eye were not uniformly consistent. The culture from one of its tissues sometimes yielded a heavy growth of gonococci, while that from another part of the same eye contained few colonies or none. In general, cultures from the anterior surface of the lens most frequently contained the largest number of gonococci, those from the ciliary body came next, and those from the aqueous and the vitreous humors third and fourth, in order of decreasing incidence. In fact, cultures from the vitreous so seldom yielded the gonococcus as to be insignificant. In most of the experiments time did not permit total excision of the ciliary body and adequate maceration by grinding. If a culture from any part of an eye contained gonococci, that eye was regarded as infected at the time of its enucleation.

In the microscopic sections, gonococci stained a darker blue than the corneal tissues and were more easily seen in those edematous tissues which stained more lightly. Typical pairs could sometimes be seen, although more commonly the two halves were not in the same plane. Not uncommonly, especially in the cornea, no gonococci of the usual morphologic character were seen. Instead, larger blue, globoid bodies,

sometimes apparently single, at other times paired, were observed. Since these bodies were seen only in eyes grossly similar to those yielding heavily positive cultures, it was felt that they represented degenerating, partially autolyzed, organisms. The gonococci appeared to be extracellular almost as often as they were intracellular. Not all the rabbits were albinos, and the intraocular pigment was sometimes confusing, with the hematoxylin-eosin-azure stain, however, the pigment had a definite dark brown color and was easily distinguished from the dark blue of the gonococci with the higher powers of the microscope. Nodal points in the fibrinous exudate often resembled gonococci, when fibrin was seen in the immediate or the intermediate vicinity, therefore, no organism was called a gonococcus unless it was quite typical. On the whole, then, a number of factors prevented easy identification of the gonococci. Nevertheless, histologic study of eyes in groups of animals yielding positive cultures did reveal gonococci, while eyes of groups of animals with negative cultures showed none.

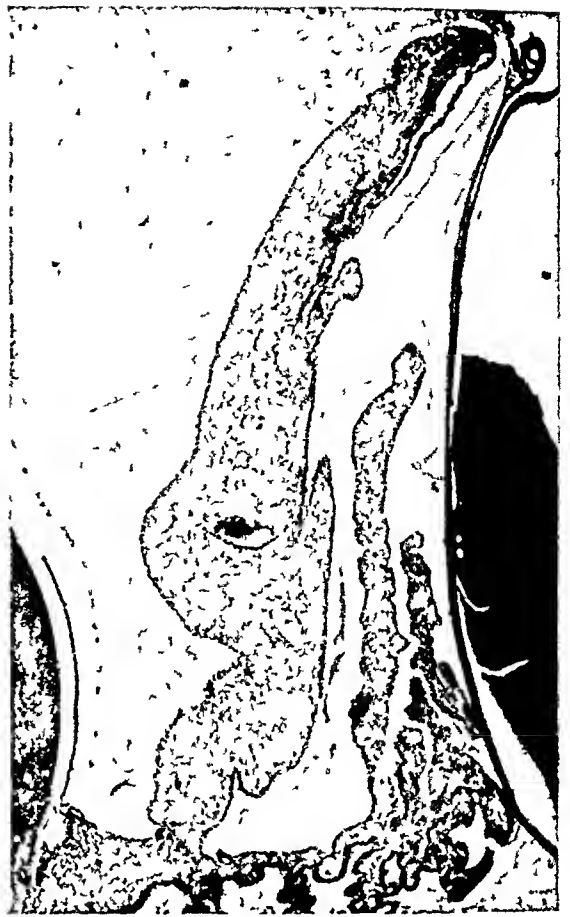
In order to determine whether mere survival of organisms or actual multiplication occurred in the anterior chamber, several series of eyes were inoculated with approximately 200,000 gonococci and enucleated at intervals up to twenty-four hours thereafter. The ocular contents were then macerated, serially diluted and cultured. The results showed that at the end of twenty-four hours a definite increase in the number of viable gonococci had occurred.

To estimate the number of gonococci required to infect, inoculations of various dilutions of the suspension of gonococci were made. The eyes were then cultured after twenty-four hours. Of 266 eyes inoculated with approximately 20,000,000 gonococci, the organisms were obtained on culture in 93 per cent, of 32 eyes inoculated with 2,000,000 gonococci, in 84 per cent, of 28 eyes inoculated with 200,000 gonococci, in 82 per cent, of 32 eyes inoculated with 20,000 gonococci, in 65 per cent, of 26 eyes inoculated with 2,000 gonococci, in 46 per cent, of 22 eyes inoculated with 200 gonococci, in 45 per cent, and of 10 eyes inoculated with 20 gonococci, in none. Thus, 200 organisms appeared to be the minimal infecting dose.

The most convenient criterion of the duration of infection was the length of time viable gonococci could be recovered from inoculated eyes. This was determined by inoculating a series of eyes with approximately  $2 \times 10^7$  gonococci each and then killing the animals at regular intervals and making complete cultures of their eyes. The results showed that during the first week there was a progressive decrease in the percentage of eyes from which viable gonococci could be cultivated. At the end of the week slightly more than a third of the eyes were still infected. Thereafter, the proportion of infections with viable gonococci continued to be about the same, although the observations were made at longer intervals. These results indicated that the infection became



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Figure 2  
(See legend on opposite page)

chronic in approximately a third of the eyes and persisted for as long as fourteen weeks, the maximum period of observation

Injection of sterile saline solution into the anterior chamber after aspiration of the aqueous resulted in slight conjunctival hyperemia with complete clinical recovery in a day. When enucleated after twenty-four hours, the eyes showed a slight fibrinous and noncellular exudate in the anterior chamber, with a few polymorphonuclear leukocytes enmeshed in the angle of the anterior chamber (fig 2, 1, 2)

Sections of eyes enucleated twenty-four hours after inoculation with gonococci (fig 2, 3) showed extensive fibrinous and cellular exudate. The exudate tended to form a layer overlying the iris. The cells were predominantly polymorphonuclear leukocytes, which, together with clumps of fibrin and debris, filled the meshwork of the angle of the chamber. Similar sections from eyes a week after inoculation showed relatively few leukocytes in the anterior chamber. The ciliary body was at times infiltrated with polymorphonuclear leukocytes and relatively more round cells than in the eyes at twenty-four hours (fig 2, 4). In other eyes the picture was that of a quickly subsiding acute inflammatory process with a few signs of permanent or residual change (fig 3, 5). Many bodies resembling gonococci were to be seen, but none which was typical.

In another series of 38 rabbits, the eyes were inoculated and observed for periods of two to fourteen weeks. Repeated cultures of the aqueous humor and agglutination and complement fixation tests on the serum were made, as well as cultures of the lens and ciliary body at autopsy. The results are reported in detail elsewhere<sup>62b</sup>. In 49 of the 76 eyes gonococci were recovered at some time during life or at autopsy, in 27 of the 76 eyes they were not. In 18 of the eyes gonococci were demonstrated at some time during life but not at autopsy, in 10 of the eyes gonococci were cultivated for the first time at autopsy.

Since the study of this series of eyes was virtually completed before the significance of the appearance of the inoculated eyes was appreciated, another, but smaller, series was initiated and studied with this point in mind. This series comprised the 22 eyes of 11 rabbits. Inoculation was effected by the modified method, requiring only a single needle

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Fig 2<sup>62</sup>—Photomicrographs, showing the angle of the anterior chamber and its surroundings,  $\times 32$ . 1, normal eye. The lens fell out during sectioning. 2, twenty-four hours after injection of isotonic solution of sodium chloride. Note the curled, torn capsule of the lens, indicating that it had been injured during injection. The iris and ciliary processes were moderately edematous. Slightly fibrinous, non-cellular exudate was present in the anterior chamber. 3, twenty-four hours after inoculation with gonococci, showing moderate fibrinous exudate with many polymorphonuclear leukocytes. 4, one week after inoculation with gonococci. Note the moderate number of leukocytes in the contracting fibrinous exudate. A heavy focal polymorphonuclear and lymphocytic infiltration, together with some gonococci, was present at the root of the iris.





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Figure 3

(See legend on opposite page)

puncture The second of the two strains of gonococcus was used In 6 of the rabbits the lenses were deliberately torn by the hypodermic needle at the time of inoculation, these eyes will be referred to, hereafter, as "injured" In the other 5 rabbits, sufficient care was taken to make reasonably certain that the lenses were not injured, these eyes will be referred to as "uninjured"

The table shows the results of postmortem examinations for gonococci in this series The eyes were observed every two to seven days over a period of two to five weeks The 12 injured and the 10 uninjured

*Bacteriologic and Histologic Demonstration Post Mortem of Gonococci  
in Rabbit Eyes*

	Injured Eyes	Uninjured Eyes
Number of eyes cultured	6	5
Number of eyes yielding gonococci on culture	5	0
Number of eyes examined histologically	6	2
Number of eyes showing gonococci histologically	5	0
Total number of eyes	12	7*

\* Three other uninjured eyes were apparently normal and were neither cultured nor sectioned

eyes were then enucleated, 1 eye of each rabbit was cultured and the other prepared for histologic study It was later regretted that 3 of the uninjured eyes, although they were to all appearances completely normal at the time of killing the animal, were neither cultured nor sectioned

Fig 3<sup>62-5</sup>, angle of the anterior chamber and surroundings one week after inoculation with gonococci,  $\times 32$  A mild, relatively noncellular residual inflammation was present 6, eye 47L of figure 4, two days after inoculation with gonococci The lens was not traumatized The cornea was moderately opaque A heavy generalized exudate was present in the anterior chamber 7, same eye as that shown in 6, on the eighth day after inoculation The membrane was dense but was localizing to the pupillary space Some vessels were present in the cornea 8, same eye, on the twenty-first day The exudate was still more shrunk and adherent to the lens Vessels persisted in a single sector of the cornea 9, same eye, on the thirty-sixth day The cornea was normal Residual membrane was adherent to the anterior surface of the lens, with posterior synechias 10, eye 48L of figure 4, four days after inoculation with gonococci The lens was not traumatized A moderately heavy exudate was present in the anterior chamber Moderate vascularization was present at the periphery of the cornea 11, eye 44R of figure 4, twenty-one days after inoculation with gonococci The lens was traumatized The cornea was deeply opaque, rough and vascular 12, eye 48R of figure 4, four days after inoculation with gonococci The lens was not traumatized A moderately heavy membrane protruded into the anterior chamber from behind and around the pupillary margin 13, same eye as that shown in 12, on the eighth day after inoculation The membrane was considerably smaller and thinner 14, eye 43R of figure 4, eight days after inoculation with gonococci The lens was traumatized The pupil was slitlike 15, eye 42L of figure 4, twenty-one days after inoculation with gonococci The lens was traumatized The pupil was piriform, with anterior and posterior synechias.

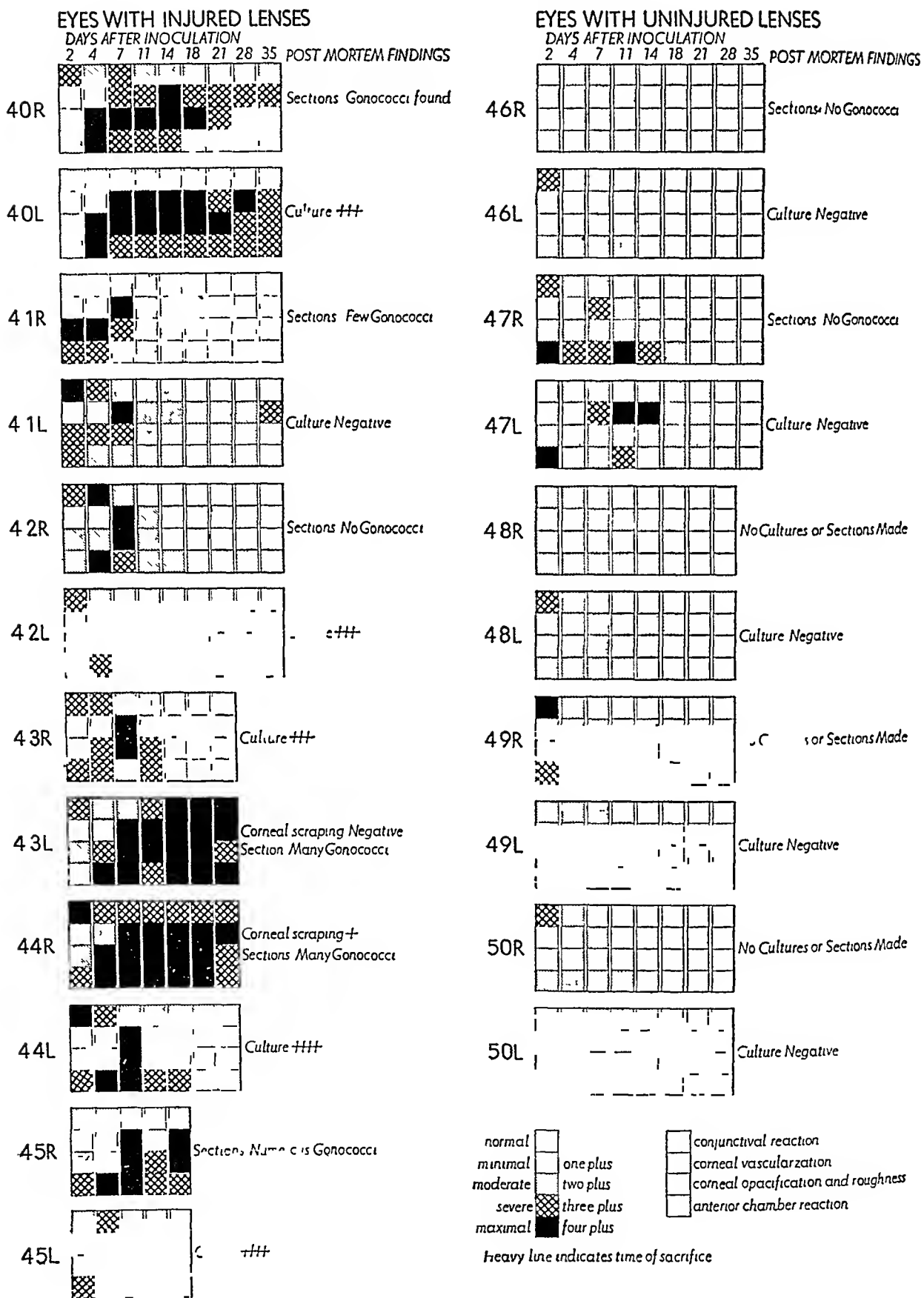


Figure 4

(See legend on opposite page)

From 2 of the injured eyes some of the superficial corneal tissue was scraped and cultured at the time of enucleation. One of these 2 cultures yielded gonococci. The 2 eyes were subsequently studied histologically, both showed numerous gonococci in the sections.

Figure 4 shows in graphic form the course of the infection in each of the eyes of this series. The observations were divided into four categories: conjunctival reaction, corneal vascularization, corneal roughness and opacification, and reaction of the anterior chamber (fig 3, 6 to 15).

The conjunctival reaction included conjunctival discharge, hyperemia and chemosis. A serous or mucoid conjunctival discharge was noted in all eyes on the first few days after inoculation. It was slightly more profuse in the injured eyes. By the end of the first week it had almost completely subsided. Repeated cultures of the discharge yielded no gonococci. Conjunctival hyperemia, seen in all the eyes, reached its maximum during the middle of the first week and was severe in the injured eyes. It disappeared in the uninjured eyes by the end of the week but persisted until the eighteenth day in a majority of the injured ones. Chemosis was present in all eyes for several days after inoculation, no difference was noted between the two groups. The recurrence of the conjunctival reaction in 2 of the injured eyes during the final week of study represented a change associated with the development of glaucoma and staphyloma in those 2 eyes.

Corneal vessels (fig 3, 10) began to grow inward from the periphery at about the end of the first week in all eyes. This process was generally much severer in the injured eyes, varying from a slight peripheral vascularization, in the corneas which were transparent, to extensive vascularization of all but the vertex, in the corneas which were rough and opaque. During the third week the vascularization in the uninjured eyes, never severe, began to recede, whereas that of the injured eyes remained much the same.

Corneal opacification developed in 6 of the uninjured eyes. Four of these eyes cleared up within eleven days, the other 2 remained opaque until the twenty-first day, and severe roughness of the corneal surface developed during this period. Corneal opacity was present in all the injured eyes, reaching its maximum at the end of the first week, the opacity assumed a deeply crackled appearance, like isinglass, and was associated with roughness of the surface in 10 of the 12 eyes. Clearing of the corneas then began, although more than half the eyes remained opaque to some extent until the end of the study (fig 3, 11).

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Fig 4<sup>62</sup>—Diagrammatic representation of the changes observed during the course of gonococcic infection in eyes with injured and with uninjured lenses. In each block, the top row of squares indicates conjunctival reaction, the second row, corneal vascularization, the third row, corneal opacification and roughness, and the bottom row, reaction of the anterior chamber.

The reaction in the anterior chamber consisted of a grayish white, milky exudate in all the eyes during the first week and was greatest about the middle of the week. In those eyes in which the corneas were sufficiently clear to make observation possible, the exudate seemed to be curling forward into the anterior chamber around the pupillary margin from behind the iris (fig 3, 12 and 13). A small hypopyon was present in some of the uninjured eyes. During the second week the exudate condensed to a heavy white membrane, which by the end of that week had disappeared in all but 1 eye. In the injured eyes the corneal changes rendered observation of the anterior chamber more difficult. The exudate, however, was considerably heavier, and a large hypopyon was present in most of the eyes, persisting until the end of the study in one fourth of them. In some a layer of hemorrhage overlay the hypopyon. All the irises showed a variable, but generally severe, vascular engorgement. In the later stages, in the uninjured eyes, evidences of atrophy of the iris appeared. Formation of synechias, both anterior (iris to posterior surface of cornea) and posterior, led to abnormal pupillary shapes (fig 3, 14, 15). Virtually all the uninjured eyes had assumed a normal appearance by the fourth week. This was not the case in the injured eyes.

The intraocular tension was elevated for a short period in 2 of the uninjured eyes. It was elevated in 1 injured eye on a single occasion during the second week, in 2 other injured eyes, both of which became staphylomatous, the tension was persistently elevated from the eleventh to the thirty-fifth day. Eyeballs similarly studied, though not included in this particular series of observations, have been found to have ruptured on occasion.

It should be noted here that some of the eyes observed during this study, though not in this series, showed pseudogliomatous masses in the vitreous. No chorioretinitis was observed at any time, and it appears unlikely to have occurred, since the histopathologic changes essentially were those of anterior uveitis. Optic neuritis was looked for but was not seen at any time. Some of the eyes appeared to have posterior subcapsular polychromatic opacities of the lens, of the kind typically seen in association with inflammations of the posterior segment (Bellows<sup>63</sup>), although the pathologic process appeared to be confined to the anterior segment.

Histologic sections were made of 6 injured and 2 uninjured eyes.

In the uninjured eyes the following features were apparent. The cornea was normal or showed only an occasional obliterated blood vessel with slight cellular infiltration surrounding it. The anterior and posterior chambers contained no fibrin and few cells. The angle of the

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63 Bellows, J. *Cataract and Anomalies of the Lens*, St. Louis, C. V. Mosby Company, 1944, pp. 378-384.

chamber was normal. The iris and the ciliary body were mildly infiltrated with round cells and were not engorged (fig 5, 16). The ciliary processes were virtually normal.

The eyes with injured lenses, on the other hand, showed numerous and more extensive changes (fig 5, 17). The cornea was thickened, in some instances two or threefold. It was infiltrated with numerous polymorphonuclear leukocytes as well as macrophages. Vascularization was clearly evident, in addition to large vessels superficially placed near the corneal periphery many fine vessels, down to those of capillary caliber, were seen throughout all the layers of the stroma (fig 5, 18). The stroma itself stained poorly. Gonococci, both typical and degenerating forms, could be distinguished intracellularly and extracellularly in the cornea. The anterior chamber contained varying amounts of fibrinous exudate together with normal and degenerating leukocytes and some gonococci, all of which formed heavy accumulations on the iris and adjacent to the angle of the anterior chamber. Collections of fibrin and leukocytes were adherent to the posterior surface of the cornea (keratic precipitates), no definite gonococci could be identified in these areas. The meshwork of the angle of the chamber was filled with leukocytes and gonococci (fig 5, 19). In 2 eyes in which sections showed the site of the injury to the lens there occurred a thick membrane, consisting of fibrin and fibroblasts, as though an attempt had been made to seal off the torn capsule of the lens, within this membrane gonococci, closely associated with rounded morgagnian globules of degenerating lens material, were particularly numerous. The iris and the ciliary body showed a variable, but on the whole moderate to severe, inflammatory reaction, an occasional gonococcus could be distinguished in the iris. The ciliary processes in the more severely involved eyes were greatly edematous, covered with an albuminous exudate and apparently adherent to the lens by means of this exudate. In 1 case the cornea was grossly ectatic. The lenses were not well preserved during the process of sectioning and fell out in some instances, while shreds of lens fibers were scattered throughout the section in others. Except for slight choroidal engorgement and slight cellular infiltration (artefact?) in the vitreous, the posterior segment of the eye was normal.

#### COMMENT

The gonococcic infection experimentally induced in the rabbit eye was a true infection. Proof of this was the evidence of multiplication of the organisms and their recovery on culture.

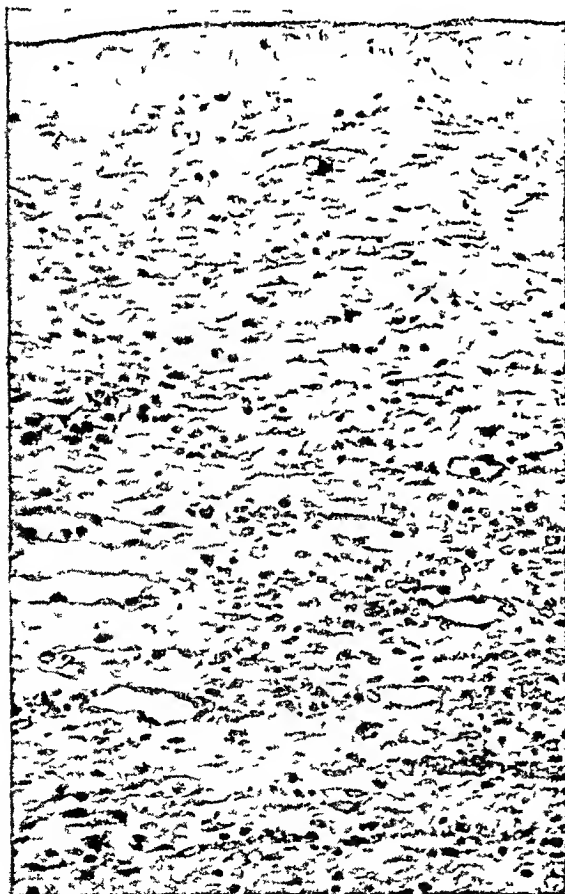
The appearance of the experimental infection was similar to that in some cases of human gonorrheal iritis. The gelatinous exudate, the intense iridic engorgement and the hypopyon and hyphema were virtually reproduced. Histologically our observations were in close agreement with those of Byers and Velhagen. The curling forward of the exudate into



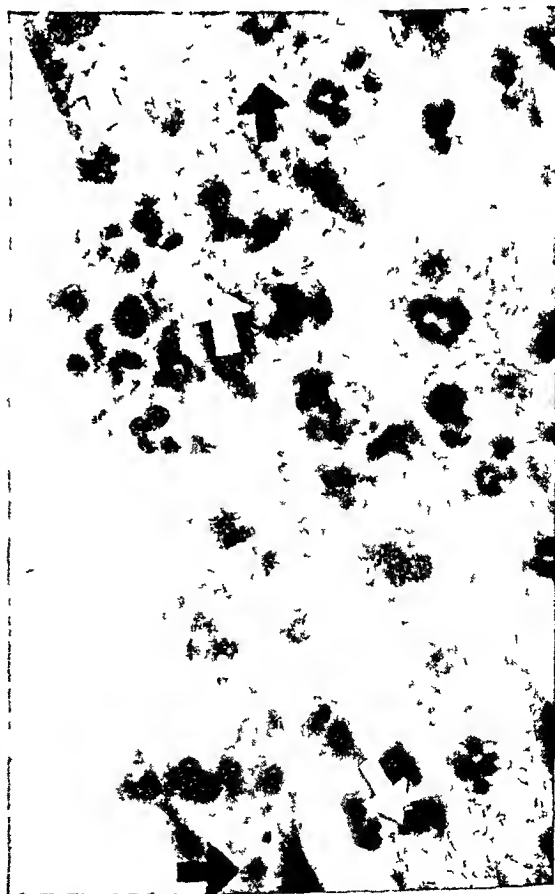
16



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18



19

Figure 5  
(See legend on opposite page)

the anterior chamber around the margin of the pupil from behind the iris probably represented the passage into the anterior chamber from the posterior chamber of the fibinocellular exudate elaborated by the ciliary body

The optic neuritis observed occasionally by clinicians in association with gonorrheal uitis has not been seen by us, although it must be admitted that in the more severely involved eyes details of the fundus could not be seen. Histologically, however, the inflammatory process appeared to be virtually confined to the anterior segment. The optic neuritis has been attributed by some authors to a toxic effect exerting its action backward from the anterior segment on the vulnerable optic nerve head. Just why the optic nerve head should be so vulnerable is not made clear. It would be just as rational to assume that gonorrheal iritis, occurring, as it does, in man as a metastatic manifestation of gonococcemia, can sometimes be accompanied with the additional metastatic involvement of the optic nerve.

Gonorrheal uitis in the past has been almost exclusively a disease of males. One possible reason for this—the instrumentation in treatment of gonorrhea in males, has already been pointed out. Another reason may be that gonorrhea in females, particularly in its chronic aspects, has only recently attained recognition.

An absolute diagnosis of gonorrheal iritis can rarely be made. The present knowledge of the immunologic reactions associated with gonorrhea is of little aid in this respect. Routine paracentesis of the anterior chamber is not ordinarily feasible, furthermore, experimentally, rabbit eyes from which the aspirated aqueous repeatedly yielded no growth on culture occasionally revealed a heavy growth of gonococci on post-mortem culture of the ocular tissues. Bits of excised iris had even less value for the demonstration of viable gonococci, even histologically the gonococcus was recognized only with difficulty. Should enucleation be done in new cases of human gonococcic iritis, the eyes would certainly yield more important information if subjected to histopathologic study than if cultured for gonococci. Ordinarily, therefore, the diagnosis of gonorrheal iritis can be only a presumptive one.

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Fig 5<sup>62</sup>—16, angle of the anterior chamber and surroundings of eye 46R of figure 4, thirty-five days after inoculation with gonococci,  $\times 120$ . The lens was not traumatized. There was a mild residual cellular infiltration of the iris and the ciliary body. The anterior and posterior chambers were clear. 17, angle of the anterior chamber and surroundings of eye 43L of figure 4, twenty-one days after inoculation with gonococci,  $\times 125$ . The lens was traumatized. There was an extensive cellular exudate in the anterior chamber. The iris and ciliary processes were moderately edematous and infiltrated. 18, portion of the cornea of the same eye as that shown in 17,  $\times 225$ . The cornea stained lightly and was greatly thickened, vascularized and infiltrated. Numerous gonococci were identified in this area. 19, detail of the meshwork in the angle of the anterior chamber from 17,  $\times 1,1000$  (oil immersion lens). Typical gonococci are indicated by black arrows, atypical gonococci, by white arrows.



The relation of injury to the lens, with its consequent liberation of lens protein, to the experimental iritis leads to interesting speculation. On the one hand, the lens, a protein-rich tissue similar to the mediums on which gonococci grow so easily, may be the single additional growth factor needed to foster multiplication of these micro-organisms in the otherwise suitable environment. On the other hand, the trauma of rupturing the capsule of the lens may be the factor which delays the normal reparative responses just enough to enable the micro-organisms to grow. The observation in the rabbit that the greatest proportion of positive cultures derives from the surface of the lens and the frequency with which gonococci are observed to be mixed with morgagnian globules tend to make the former hypothesis more acceptable than the latter, although the two are not necessarily mutually exclusive. Further work on this problem is the subject of another publication.<sup>64</sup>

The experimental infection lent itself well to in vivo testing of gonococcidal agents. For details of this work, the reader is referred to a previous paper.<sup>62c</sup> It may be mentioned here that, although relatively huge doses of systemically administered penicillin were required to control the experimental infection, as little as 2.5 units injected directly into the anterior chamber was able to do so.

Finally, gonorrheal iritis is a disease which can well bear more important consideration by ophthalmologists. The war-induced increase in the incidence of venereal diseases will probably lead to an increase in the incidence of their complications and sequelae, sulfonamide compounds and penicillin notwithstanding.

#### SUMMARY

A technic for producing gonorrheal iritis in the rabbit eye is reported.

The percentage of eyes yielding cultures containing the gonococcus fell progressively during the first week after inoculation. Thereafter, the infection became chronic in about one third of the eyes. It seemed that injury to the lens was a major factor in making the infection chronic.

The eyes exhibited many of the gross appearances of human gonorrheal iritis. The histologic picture was initially that of an acute fibrinocellular response and later that of a chronic inflammatory process. The inflammation remained localized to the anterior segment of the eye.

Dr. Arlington C. Krause, of the Division of Ophthalmology, Department of Surgery, of the University of Chicago, gave aid in this study.

Figures 2, 3, 4 and 5 were originally published in the *Journal of Infectious Diseases* and are reproduced by permission of its editors and of its publisher, the University of Chicago Press.

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<sup>64</sup> Drell, M. J., Bohnhoff, M., and Miller, C. P. The Role of Lens Substance in Experimental Gonorrheal Iritis, *Am J Ophth* 29:1263-1272, 1946.

## REPAIR OF ORBITAL DEFORMITIES WITH GLASS WOOL

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Note has previously been made of the frequency with which depressed fractures of the orbital floor are associated with traumatic enophthalmos<sup>1</sup> When the injury has been severe enough to necessitate removal of the globe, attempts at installing a satisfactory prosthesis are usually cosmetically unsatisfactory The chief blemish is the loss of fulness normally present in the upper lid and its replacement by a disfiguring sulcus To a less degree this defect is often seen after an uncomplicated enucleation and may possibly be due to atrophy of orbital fat associated with trauma incident to the operative technic Particularly, when an attempt is made to secure a long stump to the nerve, the enucleation scissors may perforate Tenon's capsule and injure the blood supply to fat lobules

It has been found that both types of defect may be remedied by the subperiosteal insertion of inert material in the floor of the orbit so as to restore the orbital volume to its original mass<sup>2</sup> Many materials have been so used These include autogenous and preserved cartilage, autogenous and preserved fascia lata, bone, tantalum wool, plates, ribbon and acrylic plates

The purpose of this preliminary communication is to suggest a material which, so far as is known, has not been employed for this specific use Glass has been used for many years for both immediate and delayed implants in the orbit It has been well tolerated, its chief defect being the possibility of the glass sphere breaking Further research by glass manufacturers has produced glass in many new forms It has been made into yarn, wool and cloth, which have come to have certain applications in surgical procedures Because of these uses, extensive investigations have been carried out to determine its toxicity for human tissues<sup>3</sup> Increasing use of glass wool as an insulator, both

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From the Department of Ophthalmology, Columbia University College of Physicians and Surgeons, and the Institute of Ophthalmology of the Presbyterian Hospital

1 Pfeiffer, R L. Traumatic Enophthalmos, Arch Ophth 30:718 (Dec) 1943

2 DeVoe, A G. Experiences with the Surgery of the Anophthalmic Orbit, Am J Ophth 28 1346, 1945

electric and thermal, in industry has prompted scrutiny of the health of workers engaged in its production. Pneumoconiosis or other irritation to the lungs has not occurred. Glass wool, being composed of pure glass filaments, is nonabsorbent, is not affected by tissue fluids or enzymes, does not produce toxins or allergic reactions, is not susceptible to attack by bacteria and is not considered carcinogenic<sup>4</sup>. It has been used by dentists for packing root canals<sup>5</sup> and by surgeons as suture material<sup>4</sup> and, in the form of cloth, as dressings for direct application to burned surfaces<sup>6</sup>. It can be boiled or autoclaved indefinitely.

With these facts in mind, it was decided to use the material in fractures of the orbital floor. All other substances tried have presented some undesirable feature. The permanence of autogenous and preserved cartilage grafts is open to question. Bone must be autogenous and



Appearance (A) prior to and (B) after insertion of glass wool into the orbit

requires a secondary operation for its procurement. Tantalum is heavy, radiopaque and subject to the development of high heat by induction should diathermy be inadvertently used. Certain patients are sensitive to acrylic compounds as they are presently made. In

3 Sulzberger, M. B., and Baer, R. L. The Effects of Fiberglas on Animal and Human Skin, *Indust Med.* **11** 482, 1942. Siebert, W. J. Fiberglas Health Hazard Investigation, *ibid* **11** 6, 1942. Heim, B. J. Hazards of Exposure to Glass Wool, Glass Frit, or Foam Glass, *J. A. M. A.* **124** 187 (Jan 15) 1944.

4 Scholz, R. P., and Mountjoy, P. S. Fiberglas Suture Material, *Am J Surg* **55** 619, 1942.

5 Maeth, H. Fiberglas Used as a Root Canal Filling Material, *Dent Digest* **51** 555, 1945.

6 Hirshfeld, J. W., Williams, H. H., Abbott, W. E., Heller, C. G., and Pilling, M. A. Significance of the Nitrogen Loss in the Exudate from Surface Burns, *Surgery* **15** 766, 1944.

addition, acrylic plates must be preformed and are not easily adapted to varying conditions encountered at the operating table

Some form of wool has seemed logical, since it can be packed into the apex of the orbit and into inaccessible crevices, which are often present in fractures of the orbital floor. The introduction of "fiberglas" provided such a wool in suitable material.<sup>7</sup>

The operative procedure is essentially the same as that described previously for the subperiosteal implantation of cartilage in the floor of the orbit.<sup>2</sup> Instead of insertion of cartilage, however, a mass of "fiberglas" yarn is rolled into a ball, soaked in solution of penicillin for ease in handling and then packed firmly into the orbit until the eyeball has attained its proper level or until, in the anophthalmic socket, the upper lid has attained its normal full contour. The photographs show the preoperative and postoperative appearance of a patient in whom this procedure was carried out. This patient had traumatic enophthalmos with fracture of the orbital floor following a gunshot injury. The eye, amblyopic because of extensive traumatic chorioretinitis, was retracted 4 mm and depressed a similar amount. A satisfactory cosmetic result was obtained after the insertion of glass wool. Similar results have also been obtained with patients who have had enucleations associated with loss of orbital volume.

It is believed that glass wool provides an inert, permanent and easily handled material for repairing defects which are primarily the result of deficiency in orbital content.

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7 "Fiberglas" is glass in the form of fiber or filament made by the Owens-Corning Fiberglas Corporation, Toledo, Ohio

## BINASAL HEMIANOPSIA

JOSEPH IGERSCHEIMER, M D

BOSTON

**B**INASAL hemianopsia is still a riddle in many respects and I can only present a critical report, including an interesting observation of my own, which in itself makes the problem still more difficult. A great deal has been published on binasal hemianopsia, but little is to be found in textbooks about this anomaly of the visual fields, probably because it is rarely encountered in individual practice.

I shall first present my own case.

### REPORT OF A CASE

A man aged 59, with chronic syphilis, came to the outpatient department of the Boston City Hospital for the first time on July 1, 1940, with the complaint that vision in his right eye had been gradually becoming worse in the past eight months and that reading with this eye was then very difficult. Vision was 3/200 in this eye and 20/70 in the left eye. Ophthalmoscopic examination revealed nothing abnormal. There was a slight contraction of the field in the nasal lower quadrant in the right eye and no contraction of the field in the left eye. Five weeks later the right eye did not show any change, whereas vision in the left eye was only 20/200, instead of 20/70. Again, five weeks later, on September 15, vision was found to be greatly deteriorated on both sides, it was limited to seeing fingers at a distance of 1 foot (30 cm) in the right eye and of 5 feet (150 cm) in the left eye.

The pupillary reaction in the right eye was sluggish. The disks were still of good color. There was binasal quadrantanopsia, with a central scotoma in the right eye (fig 1).

Except for the visual deficiency, the patient had few complaints—some headache, which was not severe, but no dizzy spells.

He was transferred to the neurologic service. The only neurologic abnormality noted was diminution to absence of the ankle jerk on the right side. The examiners also found independently a bilateral defect in the nasal quadrant of the visual field. A roentgenogram of the skull showed thinning of the floor of the sella turcica and of the posterior clinoid processes, there was an irregular area of calcification just above and anterior to the sella, probably in the walls of the internal carotid artery. In the pneumoencephalogram the shadow of the third ventricle appeared enlarged, but not displaced. The perichiasmal spaces were apparently not filled with air. There were no symptoms of involvement of the pituitary body.

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Read before the New York Academy of Medicine, Section of Ophthalmology, March 18, 1946. A discussion of this paper was published in the October 1946 issue of the ARCHIVES, page 515.

On Oct 18, 1940, an exploratory operation was performed by Dr Donald Munro. The dura was pulsating and not particularly tense. On elevation of the right frontal lobe it was apparent that a tumor of some sort lay in relation to the right optic nerve, which was superomedial to the mass. The tumor was pulsating and was about the size of an English walnut. It had the appearance of an aneurysm, and consequently no attempt was made to expose it in detail. The wall was punctured with a fine hypodermic needle, and arterial blood was withdrawn into a syringe. The puncture hole did not bleed. The wound was closed.

Recovery was good, and three weeks later, just before the patient was discharged, another determination of the field revealed total nasal hemianopsia, instead of a quadrantanopsia, in the left eye and vision in the right eye was limited to perception of hand movements in the upper part of the temporal field.

About four months later (March 21, 1941) the patient returned to the outpatient department of the ophthalmic service. He was in good health and spirits. In the

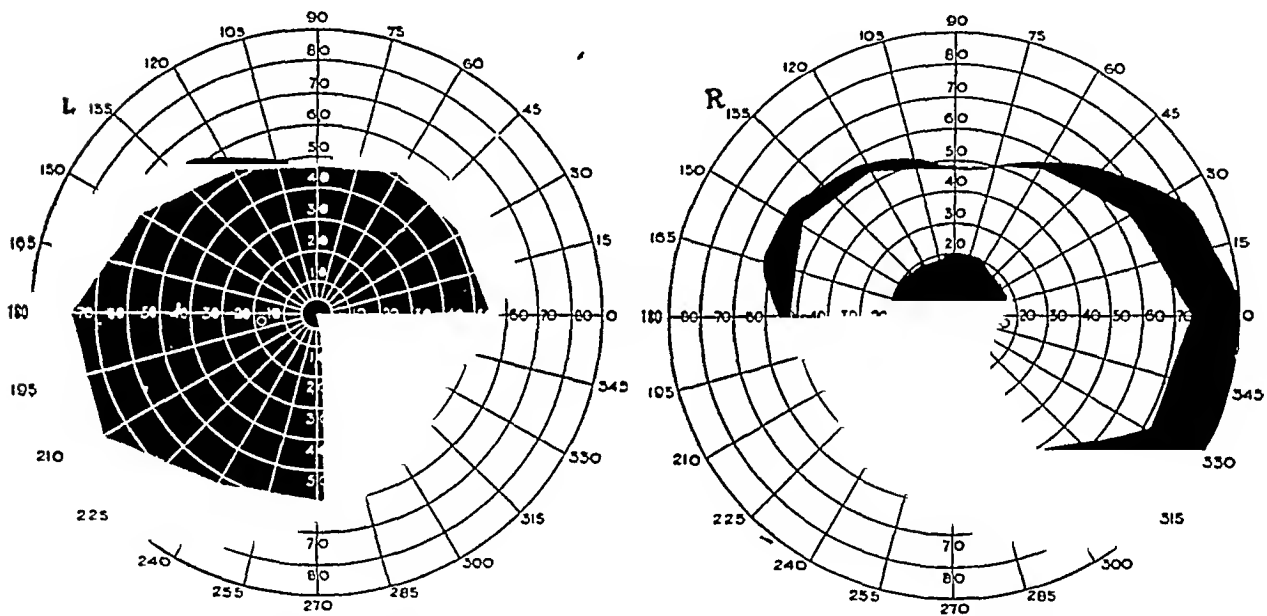


Fig 1—Visual fields at time of first examination, showing binasal quadrantanopsia with central scotoma in right eye

right eye only a small portion of the visual field remained and the disk was pale, but in the left eye vision was improved from counting fingers to 20/50, there was still some contraction of the lower nasal part of the field. Some time later vision in this eye became 20/20 again, and the field showed no residual defect. The disk was of normal color (fig 2).

Such was the visual status up to the time of writing. The patient, meanwhile, had had several attacks of unconsciousness and convulsions, which were considered post-traumatic epilepsy. A roentgenogram in September 1945 showed curvilinear areas of calcification slightly to the right of the midline and anterior to the pituitary gland. This area of calcification measured about 2 cm by 8 mm and was probably due to an aneurysm of the circle of Willis. The floor of the sella was depressed and thinned. The posterior clinoid processes showed slight thinning.

*Summary*—An aneurysm lay in relation to the right optic nerve, being lateral to and apparently covered by the nerve. How far back this

aneurysm reached could not be determined. Binasal quadrantanopsia was also present, combined on the right side with a central scotoma. In the left eye the macular fibers must also have been involved to a certain degree, as vision had deteriorated to such an extent. At the exploratory operation the tumor was not touched except for withdrawal of a very small amount of blood. Nevertheless, vision in the left eye regained its full strength. Interesting, in the first weeks after the operation total nasal hemianopsia developed in the left eye, then the defect of the visual field disappeared altogether. On the left side the optic disk had always a normal color, whereas on the right side the degeneration was progressive.

From the patient's history, it is probable that the visual disturbance started with a central scotoma on the right side. The nasal defect

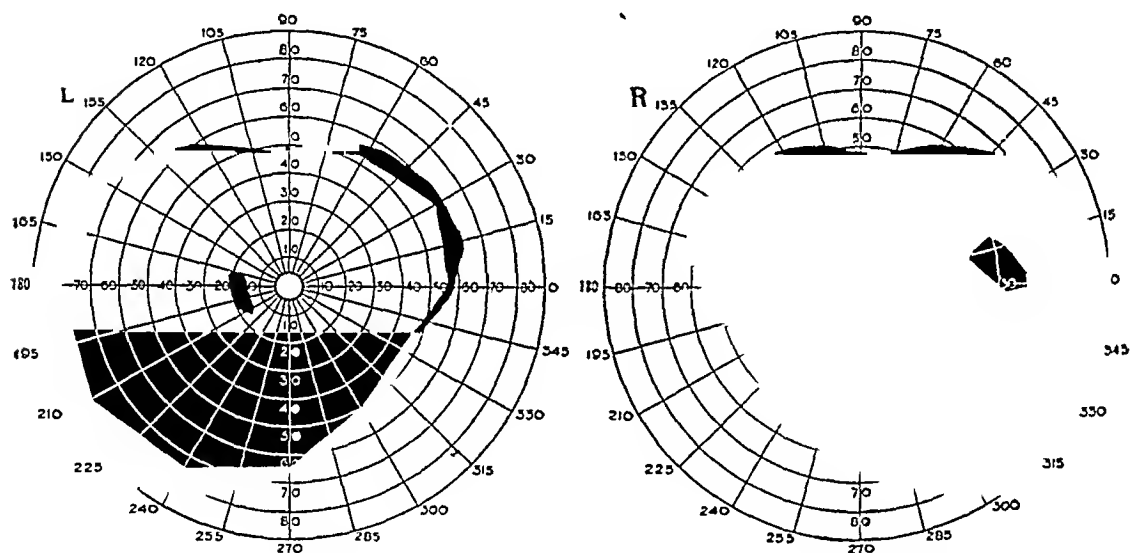


Fig 2—Visual fields after operation, showing recovery of vision in left eye

was first found in the right eye and later also in the left eye. It seems to be not unusual that bitemporal, as well as binasal, hemianoptic defects are first noted in one eye (Holmes,<sup>1</sup> Baudouin, Halbron and Deparis<sup>2</sup>).

The aneurysm in my case belongs to the supraclinoid type of saccular aneurysms, which have no relation to the cavernous sinus and are therefore not complicated by ocular palsies or involvement of the fifth cranial nerve (Jefferson<sup>3</sup>). Although the patient had long-standing syphilis, it is doubtful whether the aneurysm had any relation to the syphilitic infection, as most aneurysms of the circle of Willis

1 Holmes, G. *Tr Internat Ophth Cong* 5 65, 1929

2 Baudouin, A., Halbron, P., and Deparis, M. *Rev neurol* 2 531, 1934

3 Jefferson, G. *Bram* 60 444, 1937

are found in nonsyphilitic persons (Fearnside,<sup>1</sup> Jefferson,<sup>3</sup> Ayer<sup>5</sup>) Supraclinoid aneurysms comprise those of the anterior cerebral and the anterior communicating artery

It seems characteristic of this kind of aneurysm for the visual fields to vary or fluctuate In my case there was a steady progression for the worse, but the patient was not often enough confronted with tests of visual function to permit confirmation or denial of such a variation

Unilateral amaurosis (or amblyopia) and bitemporal hemianopsia seem to be the favorite visual defects associated with supraclinoid aneurysms, as well as with aneurysms of the internal carotid artery Homonymous hemianopsia occurs occasionally (e g, Dott,<sup>6</sup> case 6) Of 12 cases reported by Walsh and King,<sup>7</sup> with aneurysms of the internal carotid artery or the anterior branch, there was bitemporal hemianopsia in 1, paracentral scotoma on one side in 1 and apparently normal visual fields in 6, in 4 cases the fields were not determined Jefferson<sup>3</sup> stated that involvement of the inferior fields in the early stages is in favor of the diagnosis of aneurysm rather than of tumor of the pituitary

In the whole literature I could find only 3 cases of binasal hemianopsia Two of them (Hornicker,<sup>8</sup> Noiszewski<sup>9</sup>) were reported only briefly, without charts of the visual fields In Hornicker's case the diagnosis was made roentgenographically, in Noiszewski's, on the basis of a bruit In a third case, in Olivecrona's service, reported by Sjoqvist,<sup>10</sup> the diagnosis was also made by roentgenographic methods As in my case, binasal quadrantopsia was found, a clinical observation difficult to bring in line with an aneurysm of the internal carotid artery My case seems to be the first instance of binasal hemianopsia in which the lesion was verified by autopsy As in other cases of saccular aneurysm, arteriosclerosis was present and was evident in the roentgenograms as calcification

There now arises the main question—how to explain binasal hemianopsia in general, and a case like mine in particular Can binasal hemianopsia be used as a localizing sign, as one is accustomed to do in bitemporal defects?

In discussing the various sides of the question, it might be well to follow the course of the nerve fibers on their way from the optic nerve to the optic tract

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4 Fearnside, E G Brain **39** 225, 1916

5 Ayer, J B New England J Med **228** 423, 1943

6 Dott, N Edinburgh M J **40** 219, 1933

7 Walsh, F B, and King, A B Ocular Signs of Intracranial Saccular Aneurysms, Arch Ophth **27** 1 (Jan) 1942

8 Hornicker, E Klin Monatsbl f Augenh **72** 766, 1924

9 Noiszewski, K Klin Monatsbl f Augenh **39** 402, 1901

10 Sjoqvist, O Nervenarzt **9** 233, 1936



In many textbooks the discussion of the course of the nerve fiber-bundles in the peripheral visual pathways is oversimplified and makes it appear that the uncrossed fibers have always a temporal location from the optic nerve to the external geniculate body and the crossed bundles always a medial location

Dejerine<sup>11</sup> stated that although there exist crossed and uncrossed bundles in the intracranial portion of the optic nerve the corresponding fibers are not totally separated, but are partly intermingled. But he did not deny Henschen's<sup>12</sup> opinion that the uncrossed bundles are mainly in the lower temporal part of the intracranial portion of the optic nerve. This intermingling is still more pronounced in the chiasm.

In studying Wilbrand's<sup>13</sup> classic description, one finds not only that the fibers in the nasal part of the optic nerve are displaced medially by the strong pial septum in the dorsal aspect, but that a large part of the temporal fibers are turned at right angles and belong to the crossed bundles. This pial spur is microscopically the starting point of the chiasm. Most of the fibers which are going to cross in the chiasm to the other side are gathered together in the dorsomedial part of the end of the intracranial portion of the optic nerve. The fibers which are not to cross are located mainly in the lower temporal part of the intracranial portion of the nerve and seem to be separated particularly in the short distance (several millimeters) between the pial spur and the anatomic chiasm.

A large number of the nasal fibers, before they enter the chiasmal body, run through the anterior commissure to the fellow optic nerve in a downward direction and form there in the lower part the "knee". Only after this detour do they spread into the chiasm, and one can find them in the temporal part of that structure, as well as in the more medial part, but the number of the fibers is greater in the ventral layers of the chiasm than in the dorsal layers. There are also crossed fibers coming, for example, from the right optic nerve which runs toward the right optic tract, form there the so-called posterior knee and run then through the posterior commissure into the left optic tract.

Wilbrand differentiated a third group of crossed fibers, which were characterized by a more horizontal course from one lateral angle of the chiasm to the other. Wilbrand came to the same conclusion as Dejerine, namely, that everywhere in their course through the chiasm the uncrossed fibers are surrounded by crossed fibers, that they are located mainly in the temporal part of the chiasm, but that they in

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11 Dejerine, J. *Anatomie des centres nerveux*, Paris, J. Rueff, 1901, vol. 2.

12 Henschen, S. E. *Klinische und anatomische Beiträge zur Pathologie des Gehirns*, Upsala, Almqvist & Wiksell, 1890-1892.

13 Wilbrand, H. *Ztschr. f. Augenh.* 59:135, 1926. Wilbrand, H., and Saenger, A. *Neurologie des Auges*, Wiesbaden, J. F. Bergmann, 1904, vol. 3, p. 1.

part spread toward the central part without reaching the midline, and that they join in the dorsolateral part of the optic tract. According to Hartmann and David,<sup>14</sup> it is probable, but not proved, that the uncrossed fibers which spread toward the center of the chiasm come from the upper temporal quadrant of the retina. The center of the chiasm is mainly occupied by the macular fibers.

Considering these microscopic observations, it is hard to believe that pressure from sclerosed arteries or from a syphilitic exudate in the meninges on both lateral angles of the chiasm can produce a clearcut binasal hemianopsia. Also, clinical proof for such an occurrence is lacking. Only in a case reported by Behr,<sup>15</sup> in which both sides of the chiasm showed indentation by a sclerosed artery and in which the defect in the visual fields was mainly binasal was an anatomic degeneration present, increasing toward each angle. But even this case is not fully convincing. In the event, of course, that, in addition to the binasal defect, the temporal fields become defective, there is up to a certain degree no theoretic objection to the assumption of pressure from both sides as a cause of binasal hemianopsia, but often the visual field will not then be characteristic.

That the pressure on the chiasm from below causes bitemporal, and often irregular, field defects is common clinical knowledge. Only in the advanced stages of tumor of the pituitary gland do the lower nasal quadrants of the fields become involved. Binasal hemianopsia associated with enlargement of the pituitary gland, if it really occurs at all, is rare indeed.

How is it, now, with pressure from above as a cause of binasal hemianopsia?

It is true that in many cases of more or less typical binasal hemianopsia in which autopsy was performed a cerebral tumor was observed at a distance from the chiasm, but in a subtentorial location. Cushing and Walker<sup>16</sup> encountered this type of hemianopsia in 5 to 6 per cent of their 300 cases of cerebral tumor. They explained the visual defect as due to secondary hydrocephalus and distention of the third ventricle. The enlarged third ventricle lies on the dorsal aspect of the chiasm and may even extend to both angles of the chiasm. Bing (cited by Lutz<sup>17</sup>), Traquair and associates<sup>18</sup> and others really assumed that degeneration of the chiasmal fibers would be the result of such pressure. Such a

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14 Hartmann, E., and David, M. Les affections due chiasma, in Baillart, P., Coutela, C., Redslob, E., and Velter, E. *Traité d'ophtalmologie*, Paris, Masson & Cie, 1939, vol. 6, p. 877.

15 Behr, C. *Arch f Ophth* **75**:210, 1910.

16 Cushing, H., and Walker, C. B. *Arch Ophth* **41**: 559, 1912.

17 Lutz, A. *Arch f Ophth* **119**: 423, 1928.

18 Traquair, H. M., Dott, N. M., and Ritchie, R. W. *Brain* **58**: 398, 1935.

possibility cannot be denied, but there seem to be no cases in the literature to prove it. On the contrary, there is no doubt that the third ventricle can be greatly distended without any consequences to the chiasm. I have slides in my collection from a case of cerebral tumor with papilledema and enormous dilatation of the third ventricle. Vision and the visual fields were normal, and microscopic examination of the optic nerves and the chiasm in sections stained by the Weigert method did not show any degeneration. But assuming that pressure from a dilated third ventricle or a tumor in this ventricle does exert an effect on the chiasm, could this pressure be the cause of binasal hemianopsia? The basis for such an assumption must be that the uncrossed fibers are united in some part of the chiasm and can be damaged there as a unit. There was a time, long ago, when such an assumption seemed justified, for Bernheimer,<sup>19</sup> in his studies on myelination, observed that the dorsal part of the chiasm contained uncrossed fibers only. But neither Dejerine nor Wilbrand could confirm Bernheimer's results, and the idea of explaining binasal hemianopsia on the basis of a single focus in the dorsal area of the chiasm had to be abandoned. It is true, however, that in the posterior portion of the chiasm the uncrossed fibers are chiefly in the dorsal layers of the chiasm and the crossed fibers chiefly in the ventral layers, but there is nowhere an actual separate fascicle.

Thus, it is evident that binasal hemianopsia occurring in a case of cerebral tumor cannot be explained by pressure in the chiasm from secondary hydrocephalus. According to Cushing and Walker, distention of the third ventricle pushes the optic nerves downward and outward against the carotid arteries, transversely indenting the outer aspects of the nerves.

But there is another explanation which must be considered. Cushing and Walker stated that in all their cases with binasal hemianopsia there was papilledema and that this papilledema was in a rather advanced stage. In a series of cases reported by Vincent and Hartmann<sup>20</sup> showing binasal hemianopsia there was also papilledema, and in some of their observations no tumor but optochiasmatic arachnoiditis was present, in their first case it is even noted that the ventricles were very small.

Central vision was decreased in most of their cases, proving that the process in the optic nerve was not in an early stage, and besides the nasal hemianopsia there was a defect in the temporal field. Therefore, it seems most plausible to explain the binasal defect not by pressure itself but by the degenerative process in the optic nerves. It is well known that in such cases of secondary atrophy following papilledema

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19 Bernheimer, L., in Graefe, A., and Saemisch, T. *Handbuch der gesamten Augenheilkunde* ed 2, Leipzig, W. Engelmann, vol 1, chap 6, p 10.

20 Vincent, C., and Hartmann, E. *Ann d'ocul* **171** 193, 1934.

there is no regularity in the amount of degeneration. Why should not once in a while, as an accident, the uncrossed fibers in both nerves degenerate first? This explanation of accidental involvement holds true in cases of tabetic atrophy of the optic nerve with binasal hemianoptic fields. I published a case of rapid visual decrease in a man with rapidly progressive hypertensive vascular disease. Although there was microscopically widespread degeneration of the optic nerve, tests of the fields showed that the uncrossed fibers were especially involved. This case is sometimes mentioned in the literature as an instance of binasal hemianopsia, I never thought of it in this way. No one would speak of binasal hemianopsia in a case of advanced glaucoma in which only the temporal fields were still functioning.

Such a simple explanation of accidental involvement of the uncrossed fibers is, of course, not valid for cases of hemianopsia with a sharp midline and is not plausible for cases of papilledema in which the central vision is still normal.

From the foregoing discussion, I conclude that binasal hemianopsia cannot be produced by a lesion within the chiasm, or probably by a pathologic process surrounding the chiasm. This conclusion, of course, does not apply to the intracranial portion of the optic nerves, especially the part just in front of the chiasm, between the pial septum and the chiasm. Here the temporal bundles are fairly well isolated, and there is no objection to the assumption that pressure on both sides could cause a binasal field defect. In these circumstances, one can understand that binasal quadrantanopsias and hemiachiasmotropia (Lutz,<sup>17</sup> Seguni<sup>21</sup>) may occur, but never binasal hemianoptic scotomas. The classic case of pressure on the peripheral pathways producing binasal hemianopsia is that of Herman Knapp.<sup>22</sup> The internal carotid and the anterior cerebral arteries were placed aside the chiasm, being in immediate contact with its outer sides and those of the optic nerves. The pressure on the optic nerve seems to be the more important factor in producing the field defect. The chiasm and the optic nerves appeared unusually flattened and atrophic. It is interesting, but not easy to understand, that in this case the visual field of one eye became normal during the course of the disease.

Other authors, such as Lutz,<sup>17</sup> Loewenstein,<sup>23</sup> Hartmann and David<sup>14</sup> and others, similarly concluded that binasal hemianopsia can be explained only by pressure of the intracranial portion of the optic nerves against some hard tissue, probably most frequently sclerosed arteries. It is only

21 Seguni, A. *Rev. oto-neuro-oftal.* **4** 299, 1927, abstracted. *Zentralbl. f. d. ges. Ophth.* **19** 144, 1928.

22 Knapp, H. *Arch. Sc. & Pract. Med.* **1** 304, 1873.

23 Loewenstein, A. *Med. Klin.* **31** 176, 1935.

strange that, although advanced sclerosis of the circle of Willis is relatively often to be noted, binasal hemianopsia is a rare event

This discrepancy is perhaps due to the different way in which the optic nerves react to pressure from outside. It has been seen that even extreme dilatation of the third ventricle may leave no marks on the chiasm. I wish also to mention the older illustrations, in which one can see the intracanalicular portion of the optic nerve so greatly compressed by the sclerotic ophthalmic artery that a deep indentation is produced, or the nerve even is split into two parts. Nevertheless, in several cases of this type no degeneration was demonstrable anatomically. The slower and more chronic the action of such a pressure, the less, apparently, is the damage. But I wish by no means to imply that such a pressure is always harmless. The Foster Kennedy syndrome is a well known sign of a pressure effect. This syndrome, or a part of it, the central scotoma, can be produced not only by a meningioma, but occasionally also by an aneurysm (Kennedy<sup>24</sup>), optochiasmatic arachnoiditis (Yaskin and Alpers<sup>25</sup>) or sclerosis of the internal carotid arteries (Yaskin and Schlezinger<sup>26</sup>). An observation of Schloffer,<sup>27</sup> seems to be especially interesting in this, and in another, respect. A patient aged 65 was operated on for meningioma. He had extremely reduced vision in both eyes—a central scotoma and atrophy of the optic nerve in the right eye and papilledema and constriction of the nasal field in the left eye. There was also definite hyposmia. Operation and post-mortem examination revealed no tumor, but the optic nerves were flattened and distorted by sclerotic arteries. Microscopic study showed that almost the whole cross section of the right optic nerve was degenerated, although the outer visual field was good, damage to the left optic nerve was much less, but here also, there was degeneration.

It is noteworthy that in this well studied case there was no harmony between the clinical and the anatomic observations so far as the visual field was concerned. Baurmann,<sup>28</sup> in a case of cerebral tumor with binasal hemianopsia, made a reconstruction model of the optic nerves and chiasm and found that there was no parallelism between the microscopic lesions in the nerves and the indentations produced by the sclerosed arteries.

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24 Kennedy, cited by Meves

25 Yaskin, H. E., and Alpers, B. J. Foster Kennedy Syndrome with Post-Traumatic Arachnoiditis of Optic Chiasm and Base of Frontal Lobes, **34** 399 (Nov-Dec) 1945

26 Yaskin, H. E., and Schlezinger, N. L. Foster Kennedy Syndrome Associated with Non-Neoplastic Intracranial Conditions, *Arch Ophth* **28** 704 (Oct) 1942

27 Schloffer, H. *Med Klin* **30** 421, 1934

28 Baurmann, M. *Arch f Ophth* **126** 203, 1931

I conclude from these, and from other, experiences that the effect of pressure on the optic nerves differs from that of pressure on the chiasm and that in a number of cases the fibers in the neighborhood of the pressure agent are not, or are not mainly, affected. This, perhaps, explains why one so seldom sees binasal hemianopsia, although cases in which sclerotic arteries press on the peripheral optic pathways are rather frequent.

All explanations have a bearing on the question of how to explain a binasal hemianopsia in a case like mine, in which an aneurysm pressed on one optic nerve only.

One more point must be considered. This is the blood supply of the chiasm and the intracranial portion of the optic nerves. Little is known about the details of this blood supply and still less about the pathologic processes involved. These questions offer a worthwhile field of research. I was engaged in such studies, but I had no opportunity to continue them. Traquair, Dott and Russell<sup>18</sup> mentioned an interesting observation. A suprasellar tumor in a woman with bitemporal hemianopsia was successfully removed. The patient had also arteriosclerosis. Vision was good after the operation, but a short time later she became blind. Postmortem examination showed necrosis of the chiasm and the optic nerves, apparently caused by thrombosis of the small arteries. How often such or slighter nutritional disturbances occur is not known. But it may be that this factor, in addition to the mechanical one, has a certain significance.

The present case is one in which an explanation of the visual defect is especially difficult. The aneurysm lay beneath the right optic nerve and on its temporal side, and after a central scotoma and a nasal field defect had appeared in the right eye the nasal defect developed in the left eye. The effect on the left eye was only temporary and disappeared entirely some time after the exploratory operation. A similar confusing case was published by Cushing<sup>29</sup> (case 10), as well as cases by Jefferson (cases 7 and 8) and perhaps by others. Cushing observed an aneurysm beneath the intracranial portion of the right optic nerve and the right side of the chiasm. The situation would have led one to suppose that the field defects in the right eye had started with a nasal hemianopsia, stated Cushing,<sup>29</sup> but the visual trouble really started with left temporal hemianopsia. In his case, as in mine, the visual function improved greatly after operation, however, if the process has been going on too long total amaurosis may result in both eyes, even though the aneurysm is strictly one sided, as in cases described by Ogle<sup>30</sup> and by Roe<sup>31</sup>.

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29 Cushing, H. *Tr. Internat. Ophth. Cong.* **3** 156, 1929.

30 Ogle. *Brit. & For. Med.-Chir. Rev.* **36** 494, 1865.

31 Roe, H. *Proc. Path. Soc., London* **3** 46, 1850.

## CONCLUSION

I conclude with some certainty that the field of action in a case of binasal hemianopsia is not the chiasm but the short portion of the intracranial part of the optic nerve in front of the chiasm. If the lesion is unilateral and the other optic nerve is also involved, this involvement can be explained only mechanically by pressure against the nerve, probably of sclerosed vessels, or by a local nutritional deficiency. Such a nutritional pathogenesis seems more likely, for an exploratory operation would hardly change the nature of a hard artery pressing on the nerve, and could not explain improvement such as was seen in my case and in others. I believe, with Caramazza,<sup>32</sup> that the presence of binasal hemianopsia combined with unilateral central scotoma is in favor of a vascular disease in the middle fossa and against the possibility of a tumor of the pituitary body or of a suprasellar tumor.

483 Beacon Street

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32 Caramazza. *Riv oto-neuro-oftal* 50 9, 1932, cited by Schloffer.<sup>27</sup>

# Clinical Notes

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## A MODIFIED FORCEPS FOR INTRACAPSULAR EXTRACTION OF CATARACT

DAVID KADESKY, M D, SAN FRANCISCO

This capsule forceps is peculiar in the construction of the grasping jaws, that part of the blades which grasps the capsule is concave and shaped to meet a convex curve with a radius of 10 mm, thus approximating the average convexity of the anterior surface of the lens. On their under surface the blades meet each other exactly throughout their length. Their distal ends are slightly rounded, so that there are no sharp edges or points. The cross section of the blade is triangular, with the base downward, allowing any excess of capsule to well up between the blades without obstruction. Pressure is controlled by a stop, so that



Fig 1—Straight action forceps



Fig 2—Details of the jaw

the capsule is not crushed. The instrument is made in both a straight action and a cross action model, the latter permitting the surgeon to relax his wrist and fingers while manipulating the lens. There is a tendency, however, to press on the blades of the forceps, thereby opening the jaws and thus breaking the hold on the capsule. This would naturally occur if one were unaccustomed to cross action forceps. For this reason many prefer the uncrossed model.

The forceps has been used in more than 300 cataract extractions and has succeeded in subluxating the cataract in 82 per cent of the cases, in the remaining 18 per cent the capsule tore.

The instrument was made by Mr E A Black, of V Mueller & Co, Chicago  
408 S Honore

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From Green's Eye Hospital

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## USE OF ONE CONTACT LENS IN CORRECTION OF HIGH UNILATERAL MYOPIA

CHARLES LITWIN, M D, NEW YORK

Mr R D L, aged 30, an engineer, came to me for help, complaining of vision with his present spectacles.

For the past nine years he had been wearing glasses. One of 3 children, he was the only sibling with defective eyesight. His mother had a high amount of myopia in the right eye, and her left eye was emmetropic. His brother and



sister both had normal vision. His condition was identical with that of his mother. His error of refraction was as follows: Right eye,  $-13.00$  D sph, visual acuity 20/50—, left eye  $-0.25$  D cyl, axis 180, vision 20/20.

The high amount of myopia in the right eye corrected gave him a size-image difference. In August 1945 he was measured for his aniseikonia, and iseikonic lenses were prescribed. These spectacles gave him fusion and comfort, but only when the eyes were in primary fixation. As he moved his eyes in the normal ocular excursions, the "image" of the right eye appeared "barrel shaped," and diplopia was manifested. It was this condition that brought him to me for relief.

In fitting the patient with a contact lens for the right eye, I made objective studies with test lenses,<sup>1</sup> and found that the horizontal and vertical curves of the sclera were 14.0 by 13.4 mm, respectively. Although the sclera was toroidal, there was no astigmatism, either subjectively or with the retinoscope. In tests for corneal clearance, a 9.0 mm radius gave about 1.5 mm clearance, and a  $-10.00$  D correction incorporated in the contact lens gave vision of 20/50+. The duochrome test showed the eye to be emmetropic, but with a  $+1.00$  D lens in a spectacle lens over the right eye vision was improved to 20/30+, and the  $-0.25$  D cylinder over the left eye gave 20/20 vision. (The  $+1.00$  D correction incorporated in the finished contact lens changed his visual acuity with the duochrome test as well as with the Snellen letters.)

Although the  $+1.00$  D correction in the glass over the right eye while he wore a contact lens correcting his myopia really made an optical system like a Galilean telescope, it was not the size-image difference that corrected his diplopia and gave him comfort; it was the ability of the eyes to move in their natural ocular excursions without suffering the prismatic effect (since the lens moved with the eye) which gave him fusion in the eight cardinal positions.

The patient was urged to be measured again for aniseikonia, but, with the comfort he then received, he was satisfied with the contact lens and the spectacles. Without the spectacles, his vision is 20/50+, and he still has fusion in all cardinal points. He uses the contact lens while swimming and experiences no asthenopia for six to eight hours without changing.

Indeed, the use of one contact lens has made a changed man of my patient for the better.

550 Park Avenue

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1 The Master Test Set, made by the National Contact Lens Corporation, of New York.

# News and Notes

EDITED BY DR W L BENEDICT

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## GENERAL NEWS

**The Dartmouth Eye Institute Passes.**—June 30, 1947 marked the passing of the Dartmouth Eye Institute. The research man, Dr Kenneth Ogle, has joined the Mayo Clinic, the ophthalmologist, Dr Hanford L. Auten, has joined the Hitchcock Clinic, the optometrists have gone into private practice. Mr A. Ames Jr. and Mr John Pearson, who has been director of the Dartmouth Eye Institute since the death of Dr Bielschowsky, have formed the Hanover Institute.

**International Ophthalmic Council**—At the recent meeting of the International Ophthalmic Council, held in Paris, May 18, 1947, it was decided to hold the next meeting in London in 1950, the president to be Sir Stewart Duke-Elder and the vice president, Dr P. Baillart. Plans for symposiums on the following subjects were adopted: (1) "The Vegetative Nervous System and Its Disorders in Relation to the Eye", (2) "Hereditary Diseases in Ophthalmology".

**American Board of Ophthalmology.**—At the last meeting of the American Board of Ophthalmology, it was decided to replace the personal preliminary interview with a written qualifying test for all applicants. This is, in part, to save them the expense and time in traveling long distances to cities where national meetings are held. The written tests, therefore, were given simultaneously in many parts of the country on Wednesday, July 23, 1947, at 1:00 p. m., and will be given again during the winter, 1947-1948. Candidates then qualifying will be admitted to the practical examination.

Registration for Chicago, Oct. 7-12, 1947, has been closed and is limited to 60 candidates.

## UNIVERSITY NEWS

**Dr. Glen G. Gibson Succeeds the Late Dr. Walter I. Lillie**—Dr. Glen G. Gibson, who was associate professor of ophthalmology of Temple University Medical School and Hospital, has been advanced to the rank of professor and head of the department of ophthalmology.

Dr. Gibson studied at the Gonzaga University and graduated from the St. Louis University School of Medicine in the class of 1930. His internship was served at Providence Hospital, Detroit, after which he took a postgraduate fellowship in ophthalmology at the Mayo Clinic. After finishing his training at the Mayo Clinic, he came to Temple University as an assistant to Dr. Lillie and remained associated with him for ten years.

Dr. Gibson is a member of the American Ophthalmological Society, the American Medical Association, the American Academy of Ophthalmology and Otolaryngology and the College of Physicians of Philadelphia. His contributions to scientific journals have been numerous.

## SOCIETY NEWS

**Irish Ophthalmological Society**—The Irish Ophthalmological Society held a general meeting at the Royal Victoria Eye and Ear Hospital in Dublin, on May 22 and 23, 1947, with Dr H B Goulding in the chair. The following papers were submitted on the first day: "Military Ophthalmology the Mobile Ophthalmic Unit," Dr D H Douglas, "Responsibilities of Ophthalmology to Industry," Dr A J Mooney, "Orbital Metastases from Wilms's Tumor," Dr H B Goulding. The Montgomery Lecture was given by Prof Bernard Samuels, of New York, on "Problem of Sympathetic Ophthalmia." A visit was made to the Hospital Orthoptic Clinic, and cases were demonstrated in the hospital. On the second day the following papers were presented: "Proptosis Report of Cases," Dr J B McAreevey, "Blindness Following Sympathetic Ophthalmia of Six Years' Standing Operation, Recovery," and "Tumor in the Orbit of a Child, Possibly Secondary and Suggestive of That Described by Hutchinson," Dr W A Anderson, "Roentgenograms of Gross Intracranial Foreign Bodies (Battle Casualties)," Dr L B Somerville-Large, "Bone Formation in the Uvea," Prof Bernard Samuels.

**Chicago Ophthalmological Society**—The Chicago Ophthalmological Society will give a forty hour refresher course December 8 to 13, inclusive. The faculty will include members of the departments of ophthalmology of the University of Chicago, the University of Illinois, Loyola University and Northwestern University and staff members of all the principal hospitals of Chicago. Instruction will consist of didactic and practical courses, emphasis being placed on the practical courses given to small groups. Physicians practicing ophthalmology or ophthalmology, otology, rhinology and laryngology are eligible for the course. The fee will be \$100. For details, write to the registrar, Miss Maude Fairbairn, 8 West Oak Street, Chicago.

**North Carolina Eye, Ear, Nose and Throat Society and the South Carolina Society of Ophthalmology and Otolaryngology**—The second annual meeting of the North Carolina Eye, Ear, Nose and Throat Society and the South Carolina Society of Ophthalmology and Otolaryngology will be held at the Hotel Skyland, in Hendersonville, N C, on Sept 15, 16, 17 and 18. The first two days will be devoted to ophthalmology, and the guest speakers will be Dr Harold Brown, Dr John H Dunnington, Dr Jack Guyton and Dr Brittain F Payne.

**American Ophthalmological Society**—At the recent annual meeting of the American Ophthalmological Society the following officers were elected for the coming year: president, Dr Henry C Haden, vice president, Dr Bernard Samuels, editor, Dr Wilfred E Fry, secretary-treasurer, Dr Walter S Atkinson.

## PERSONAL NEWS

**Dr. Alfred E Maumenee Succeeds Dr. Hans Barkan, Who Becomes Professor Emeritus of Ophthalmology, Stanford University School of Medicine**—Dr. Hans Barkan, now clinical professor of ophthalmology and chief of the division of Ophthalmology at Stanford University School of Medicine, becomes emeritus professor on Sept 1, 1947.

Dr Alfred E Maumenee, now at Wilmer Ophthalmological Institute, in Baltimore, has been appointed professor of surgery assigned to ophthalmology, to succeed Dr Barkan. Dr Maumenee will not assume his duties at Stanford University until Sept 1, 1948. In the meantime, Dr Dohrmann Kaspar Pischel, clinical professor of ophthalmology at Stanford, will act as chief of the division until Dr Maumenee can join the staff.

**Appointment of Dr. William H. Buschke.**—Dr William H Buschke has been appointed research ophthalmologist to the Manhattan Eye, Ear and Throat Hospital, New York, and will be in charge of the Ayer Foundation Ophthalmic Research Laboratory at this hospital. The aims of the Ayer Foundation and of its research project, which was initiated by Dr R Townley Paton, are directed toward problems of the general physiology and experimental pathology of ocular tissues, with primary, but not exclusive, emphasis on the cornea. The Ayer Laboratory is being installed jointly by the Foundation and by the hospital. It is not a part of the Eye Bank for Sight Restoration, Inc., which is located at the same hospital and the research activities of which tend more toward applied problems.

Dr Buschke, who is a graduate of the University of Berlin, received his ophthalmologic training at the university ophthalmic hospitals in Berlin and in Basel and Bern, Switzerland, and has since 1938 been associated with the Wilmer Ophthalmological Institute of Johns Hopkins University and Hospital, first as research fellow and later as instructor in ophthalmology. He is a member of the American Medical Association, the American Physiological Society, the New York Academy of Sciences and the Swiss Ophthalmological Society. The principal subjects of his previous work are role of vitamins in ophthalmology, physiologic factors controlling light sense, experimental and classification studies on cataracts, studies on the mechanism of secretion in the ciliary body and on the physiology of epinephrine and experimental studies on the general physiology and pathology of the corneal epithelium (mitosis, nuclear pathology, wound healing). Several of these studies have been carried on during his research association for the past nine years, and in cooperation with Dr Jonas S Friedenwald.

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## Correspondence

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### THE MODIFIED LIÉGARD CORNEOSCLERAL SUTURE

*To the Editor* —The original description of the technic for a modified Liégard corneoscleral suture in cataract surgery which Dr OTIS S LEE JR, of Iowa City, reports in the ARCHIVES of May 1947, was made by Dr E H Frisch, of Atlantic City, N J (A method for Preventing Loss of Vitreous, *Am J Ophth* 5: 81 Feb 1922). This was brought forward by Dr William Zentmayer in a comment when an almost similar suture was described before the Section on Ophthalmology of the College of Physicians of Philadelphia on April 20, 1944 (*ARCH OPHTH* 32: 522 Dec 1944).

CARROLL R MULLEN, M D, Philadelphia

2025 Locust Street

## Obituaries

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### EDWARD COLEMAN ELLETT, M D

1869-1947

Dr Edward Coleman Ellett, internationally famous for his contributions to ophthalmology, died in Atlantic City Hospital, June 8, 1947, after an attack of coronary thrombosis, suffered on the train while en route to the centennial celebration of the American Medical Association. During the previous week, at the meeting of the American Ophthalmological Society in Hot Springs, Va., he had participated freely in the discussions and seemed as usual, although he and his close friends were aware that such an attack was imminent. His practice for the past eighteen months had been restricted to consultation and surgery, but his interest in the specialty was in no wise diminished.

Dr Ellett, son of Judge Henry T. and Katherine Coleman Ellett, was born in Memphis, Tenn., Dec. 18, 1869. He was educated in private schools in Memphis, attended for two years the Southwestern Presbyterian University at Clarksville, Tenn. (now Southwestern College, at Memphis) and received his degree of Bachelor of Arts from the University of the South, Sewanee, Tenn., in 1888. These two institutions later conferred on him the honorary degrees of LL.D. and D.Sc.—the former by Southwestern College, in 1942, the latter by the University in Sewanee in 1943. His medical degree was received at the University of Pennsylvania in 1891, where he was also honored with the Alumni Medal for the highest scholastic average in his class. After a year as resident physician in St. Agnes Hospital, Philadelphia, and a year as house surgeon at Wills Hospital, he returned to Memphis, in 1893, where he confined his practice to diseases of the eye, ear, nose and throat, and since 1917 to diseases of the eye only.

In 1896 he married Nina Polk Martin, and their union endured for over a half-century, a fine example of mutual devotion. She was the perfect complement to his professional life, smoothing out the home affairs so as to give him a maximum of time for writing and organizing his medical material. Their interest in travel was gratified by many trips abroad and to South and Central America, where the work of various surgeons was observed and lasting friendships were formed. She was with him in Hot Springs and Atlantic City. They had no children.

Dr Ellett was professor of Ophthalmology in the medical department of the University of Tennessee from 1906 to 1922, and chief of staff of the Memphis Eye, Ear, Nose and Throat Hospital from its opening, in 1926,

until his death. His main interest was in graduate teaching, and from the organization of the instructional courses of the American Academy of Ophthalmology and Otolaryngology to the present, he annually gave an hour of instruction on some subject of clinical interest. Any intern, resident or visitor who manifested the least interest in what "The Colonel" was doing was cordially invited to the operating room and was



EDWARD COLEMAN ELLETT, M.D.

1869-1947

welcomed at ward rounds. He was the motivating influence behind annual "clinic days" which for years the Memphis Society of Ophthalmology and Otolaryngology held for the interested specialists of the Mid-South area.

Dr Ellett's contributions to the literature of ophthalmology are too numerous to record. His interest was mainly in clinical ophthalmology, and his reports dealt with his long personal experience with various phases of the subject. He often remarked that one learned more from a single well developed case report than from a long paper on the subject. He particularly delighted in the programs of the American Ophthalmological Society, which always gave him an opportunity to place on record his own experience with an unusual problem. His reports were concise and direct and were typical of his behavior in the office and the hospital, where he always moved with a minimum of lost motion. For more than thirty years he had advocated some form of corneoscleral suture in cataract extraction and was one of the first in this country to attempt intracapsular extraction except where contraindicated. Extensive travels abroad allowed him to visit outstanding clinics and to observe various ophthalmic surgeons at work, and his practice always received the immediate benefit of such surgical procedures as appealed to him. He could converse passably in French and Spanish, but language barriers never deterred him from obtaining the information he needed. He returned from the International Congress of Ophthalmology in 1929 to apply immediately Gonin's technic in the treatment of retinal detachment. Unable to understand the presentation at the meeting, he had smoothed out all the details with Gonin during a chance meeting on a streetcar the following day.

Persistence and the attention to detail were primary virtues with Dr Ellett. His office records, written in long hand, were masterly in description, but always brief and to the point. If the diagnosis was obscure, there was no quibbling over terms, treatment was prescribed as seemed indicated and if the course of the disease was not altered in a few days there was no hesitancy in a change to some other form of therapy. There was neither dogmatism nor nihilism in his treatment of his patients, and it was often amazing to mark the improvement of patients with stubborn conditions unyielding to the accepted forms of therapy. His quiet manner and gentle touch always inspired confidence, which is itself a primary requisite in treatment.

He was a man much honored by his colleagues. In 1914 he served as Chairman of the Section on Ophthalmology of the American Medical Association and was president of the American Academy of Ophthalmology and Otolaryngology in 1926 and of the American Ophthalmological Society in 1932. In addition, he held executive positions in all local and sectional medical organizations, having been president of the Memphis and Shelby County Medical Society and of the Tennessee Academy of Ophthalmology and Otolaryngology and vice president of the Southern Medical Association. He was active in the American College of Surgeons and in the Pan-American Congress of Ophthal-

mology and was in constant attendance at sessions of the International Congress of Ophthalmology

In November 1939 the Southern Medical Association honored him with "Ellett Day," dedicated to a review of his achievements as a physician, citizen and soldier. In October 1942 Dr Ellett was associate guest of honor of the American Academy of Ophthalmology and Otolaryngology and received the Award of Merit in recognition of his services as president, member of council and instructor, as well as scientist, teacher and soldier. In May 1943 the Memphis and Shelby County Medical Society honored him with a testimonial dinner to celebrate his fiftieth year of medical practice in Memphis, at which were nine Memphis ophthalmologists and otolaryngologists who had been associated with him in private practice during those years.

For many years a member of the board of directors of the National Society for the Prevention of Blindness, and a vice president at his death, he gave freely of his time to the labors of this lay organization in the field of sight conservation. In 1939, in cooperation with the St. Louis Society for the Blind, he was given the Leslie Dana Medal "for outstanding achievements in the prevention of blindness and the conservation of vision."

A member of the original American Board for Ophthalmic Examinations, he helped to conduct the first examinations for certification in ophthalmology at the initial meeting in Memphis, thirty years ago. His interest in this was maintained, and he continued to review candidates' examination papers until last year, when he retired from the American Board of Ophthalmology, after serving as president for several years. This, too, was the occasion of a testimonial by the Board.

During World War I Dr Ellett served in France as commanding officer of Base Hospital 115, with the rank of lieutenant colonel and received a citation for "exceptionally meritorious and conspicuous service." Discharged as a full colonel in the Medical Corps of the United States Army Reserve, he has been known to all his Memphis colleagues as "The Colonel," a term of honor, endearment and respect, which he accepted modestly.

Dr Ellett was a member of Calvary Episcopal Church. His fraternal orders were Kappa Sigma and Phi Alpha Sigma. In Memphis, he belonged to the Memphis Country Club, the University Club and the Waponoca Club, which gratified his hobbies of golf, tennis and hunting, pleasures which he enjoyed to the very end of his life.

A keen observer, he maintained a varied interest in local and national affairs of government and in matters of education, both general and professional, and was a devotee of amateur sports. At 60 he began the study of Spanish and received lessons in the improvement of his tennis. His versatility and ability can best be demonstrated by the ease with



which he conducted a family tour of South America when air service was in its infancy and by the excellent game of tennis which he played until he was 72. Golf and hunting he enjoyed until his death.

The success of his professional life may be known from the expression, "Despise not the day of small things," a favorite motto which he followed throughout his daily life. Though his experience was wide and his professional attainments were great, he was always modest and unassuming, willing to listen to the suggestions of others. Indeed, he sought the opinions of his colleagues and not only was delighted to learn from the youngest of them, but always accorded the credit for new ideas to the origin from whence they came. To those of us who were privileged to work with and for him, he was a wise counselor and firm friend, a strong arm on which to rely in times of distress. His interest in his former associates and residents of the Memphis Eye, Ear, Nose and Throat Hospital was constant and unwavering. He aided those he deemed worthy in organized medicine by sponsoring their election to membership in various societies, in reviewing their case reports and theses presented to these societies and in introducing them to the membership when they were accepted. His correspondence with them was of tremendous volume. Regardless of the press of professional duties, he always had time to pen a note to a friend at the end of a hard day's work, and no plea for advice ever went unanswered.

Dr. Ellett was one of the nation's outstanding ophthalmic surgeons. He abhorred the sensational and spectacular, preferring to operate in the safest, simplest way and with a minimum of maneuvers. His manual dexterity, steadiness and surgical judgment were maintained to the very end and were the admiration of all who observed him. Although serious and hard working with respect to his professional duties, "The Colonel" had a divine sense of humor and could always break the tension of a tedious day or a difficult situation with a humorous story or remark which was perfect for the occasion. He had a most retentive memory and could cite references to ophthalmic literature which he had not reviewed for years. It was always amazing to hear him quote remarks from Horace and Tacitus or the obscure poetry of early American authors and statesmen, the result of memory training of sixty years ago.

His great influence will endure, for he was a courteous gentleman, beloved physician and skilled surgeon, a wise counselor and staunch friend.

"And when he fell in whirlwind

He went down as when a lordly cedar green with boughs

Goes down with a great shout upon the hill

And leaves a lonesome place against the sky."

RALPH O RYCHENER, M D

# Abstracts from Current Literature

EDITED BY DR WILLIAM ZENTMAYER

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## Color Sense

A CASE OF ATYPICAL ACHROMATOPSIA L L SLOAN, Am J Ophth 29:290 (March) 1946

Sloan reports a case of complete loss of color perception and a shift in the spectral luminosity curve Her findings indicate that no one of the characteristics commonly associated with typical achromatopsia is invariably present

W S REESE

## Conjunctiva.

PTERYGIUM ITS NATURE AND A NEW LINE OF TREATMENT S KAMEL, Brit J Ophth 30:549 (Sept) 1946

In the opinion of Kamel, based on facts deduced from the clinical and pathologic pictures, pterygium is an inflammatory lesion to begin with, while the degenerative changes seen in the deep layers of the conjunctiva are secondary and postinflammatory Pterygium is an irritative disease The causes of the irritation are many and various Two causes are discussed—the influence of locality and the patency of the lacrimal passages As regards the first, pterygium was common in a village where about 30 per cent of the population were stone cutters, and the condition was common in a second village owing to its location, the inhabitants being exposed to sandy dust which is blown into the village from a strip of sandy desert The principal step in the operation for pterygium as done by Kamel is dissecting the head of the pterygium from the cornea, undermining the pterygium and conjunctiva up to the canthus and cauterizing the under surface of the conjunctiva with phenol No stitches are needed

W ZENTMAYER

THE INCIDENCE OF TRACHOMA IN THE SOUTHERN HIGHLANDS PROVINCE OF TANGANYIKA H REED, Brit J Ophth 30:573 (Oct) 1946

Trachoma affects about 50 per cent of the Africans of the Bantu tribes in the Southern Highlands Province of Tanganyika The incidence varies considerably, from 13.7 per cent, in the Rungwe district, to 87.3 per cent, in the neighborhood of Kalenga Diet, dust, personal habits of cleanliness and the occupation of cattle raising, with the associated swarms of flies, are probably factors affecting the incidence On the whole the trachoma seen in the Southern Highlands Province is a mild disease

W ZENTMAYER

## Experimental Pathology

CHEMICAL TRANSMISSION OF NERVE STIMULI AND PUPILLARY MOTILITY R RODRIGUEZ and W ISOLA, Arch de oftal de Buenos Aires 18.692 (Dec ) 1943

The authors have confirmed experimentally the reality of the liberation of sympathin in the aqueous humor by stimulation of the sympathetic pupillomotor nerves, not only by excitation of the cervical sympathetic fibers but by direct stimulation of the hypothalamic center. The experiments were made on dogs. The liberation of sympathin was detected by establishing in vivo a communication of the anterior chamber of the stimulated dog with the anterior chamber of another dog. Excitation of the hypothalamic zone, besides producing bilateral mydriasis in the one dog, caused dilation of the pupil in the other dog. Also, injection of aqueous humor into the heart of a frog produced acceleration. Epinephrine-like substances were detected in the aqueous by the Bayer reaction.

It was observed that during the mydriasis produced by the hypothalamic excitation, direct stimulation of the third nerve had a normal effect on the extraocular muscles but miosis was retarded, and the stimulation had to be prolonged to produce it.

The mydriatic action of the hypothalamic stimulation is transmitted by the fibers of the cervical sympathetic nerve. When these fibers were severed, no mydriasis occurred.

The following conclusions are reached. Sympathin is liberated not only by excitation of the peripheral sympathetic fibers but by stimulation of the hypothalamic centers, the action when central being bilateral, the mydriasis is different from that produced by simple stimulation of the sympathetic fibers, the substances liberated in the aqueous humor in both instances are able to induce motility in the pupil of another animal by humoral action alone.

H F CARRASQUILLO

THE BLOOD-AQUEOUS BARRIER IN HYDROPHTHALMIC RABBITS J H SMITH, Ophthalmologica 108:293 (Dec ) 1944

The University Eye Clinic in Basel, Switzerland, has successfully bred a strain of hydrophthalmic rabbits. In the present experiments, 19 of these rabbits, of different age levels, and 9 normal rabbits were compared as to the time elapsed before the appearance of fluorescein in the anterior chamber after subcutaneous injection. It was found that there was a very considerable delay in the appearance of fluorescein in the hydrophthalmic rabbits as compared with its appearance in the normal rabbits. The weights of the rabbits and the size of the pupil in the two groups were approximately the same. The intraocular pressure in the hydrophthalmic group on an average was about 10 mm higher than that in the normal group. The author believes that these experiments prove that the rate of flow across the blood-aqueous barrier is definitely and considerably slower in hydrophthalmic rabbits than in the normal rabbits, and this suggests a reduced permeability, probably arising from atrophic conditions produced by the increased intraocular pressure in the eyes of the former.

F H ADLER

## General

## OCULAR MANIFESTATIONS OF MALNUTRITION IN RELEASED PRISONERS OF WAR FROM THAILAND H RIDLEY, Brit J Ophth 29:613 (Dec ) 1945

The eyes of some 500 released allied prisoners of war and internes from Thailand who considered that their sight had deteriorated during captivity were examined, among these no less than 100 cases of amblyopia were seen in seventeen days. The food had been inadequate in quantity and lacking in variety, being especially deficient in proteins, fats and vitamins. The three daily meals were the same, chiefly polished rice of poor quality. This was supplemented by vegetable stew containing pumpkin, yams, sweet potato, bringal, Chinese radish and Chinese cabbage.

In 90 of the patients, at the time of writing, sight had been defective for two and one-half to three years. Corrected vision varied from 1/60 to a partial 6/9. All those with scotomas and good acuity had recovered from temporary severe amblyopia. In many patients the onset was sudden, maximum disability being reached within a single day. In others it was gradual, taking months to develop. There were few complaints of day blindness. Sight was particularly defective in bright light. Many of the patients with amblyopia had suffered from pellagra, edema of the legs, dry beriberi and such minor lesions as sore tongue and perlèche, which usually accompany deficiency in the B group of vitamins. Quite a number had become nerve deaf. The fundus might show no changes even when the amblyopia was of long standing, though in many there was pallor of the temporal half of the papilla.

Forty-eight patients had optic nerve atrophy, and in 30 more the condition was regarded as doubtful. In a few instances in which temporal pallor was pronounced there appeared to be some constriction of the macular arterioles—a change probably secondary to retinal atrophy.

Ninety patients showed a small, sharply demarcated central scotoma, rarely extending more than 3 degrees, and often 1 degree or less. In the remaining 10 patients the core of the scotoma was paracentral or pericentral. Further details of the nature of the scotoma are given. No defect in the peripheral field was found with rough testing. Practically all the released prisoners showed some degree of keratoconjunctival abnormality. There was no xerosis of the cornea or Bitot's spots. The most striking feature of the limbal capillaries was their variability in size, which was often so great that aneurysms, both fusiform and sacular, were noted. There seems little doubt that the lesions described were due primarily to malnutrition, though other factors may have operated since only a small proportion of men living under the identical conditions were affected. No similar series of cases has occurred in the civilized world until this war. There seems to be no doubt that the diet was deficient generally, especially in proteins, fats and vitamins, in the absence of direct evidence that avitaminosis unsupported by other factors was the cause, it seems advisable to attribute the lesions to general malnutrition rather than to simple deficiency of the vitamin B group.

W ZENTMAYER

## General Diseases

OCULAR LESIONS IN SOME SYSTEMIC VIRUS DISEASES A SORSBY,  
Tr Ophth Soc U Kingdom 64 67, 1944

In an opening paper of a discussion on virus diseases of the eye at the annual congress of the Ophthalmological Society of the United Kingdom in 1944, Sorsby enumerates the disease of virus origin in the various structures of the eye as follows

*Lids*—Vesicular eruption of herpes zoster ophthalmicus, molluscum contagiosum, common wart

*Conjunctiva*—Some, at least, of the amicrobial forms of ophthalmia neonatorum, epidemic keratoconjunctivitis, trachoma, Parinaud's syndrome, vaccinia, and pemphigus

*Cornea*—Superficial lesions Superficial punctate keratitis, keratitis nummularis, herpes corneae, dendritic ulcer, and herpes zoster Deep lesions Disciform keratitis, interstitial keratitis, subepithelial parenchymatous opacities (keratitis parenchymatosa metaherpetica), deep marginal keratitis without ulceration as a complication of influenza, and herpes cornea posterior with recurrent labial herpes

*Uveal Tract*—Iritis and iridocyclitis occurring with smallpox, mumps, chickenpox and herpes zoster, choroiditis occurring with smallpox, Haidt's disease, sympathetic ophthalmia

*Retina and Optic Nerve and Ocular Muscle*—Involvement with general virus disease

*Lacrimal Gland*—Involvement with mumps, uveoparotid fever (possibly) disease

W ZENTMAYER

OPHTHALMOSCOPIC CLASSIFICATIONS OF ARTERIAL HYPERTENSION  
C ESPILDORA-LUQUE, Arch chilena de oftal 3 5 (Nov-Dec)  
1944

After giving the classifications of hypertensive disease based on the retinal lesions, Espildora-Luque expresses the opinion that the one proposed by Gans is the most appropriate Its simplicity and descriptive expression are unquestionable He agrees with Gans that the ophthalmologist should adopt a neutral and impartial position He should describe only his findings in the cases referred to him, leaving to the internist or the surgeon the final decision

H F CARRASQUILLO

## Glaucoma

DIATHERMIC SURGERY OF THE CILIARY BODY IN GLAUCOMA M U  
TRONCOSO, Am J Ophth 29:269 (March) 1946

Troncoso reviews the thermic methods of treating glaucoma and attempts to determine the physiologic basis of diathermic methods, their action on intraocular pressure and the damage done to the ocular structures He used rabbits for these experiments but found that the reduction in tension was not permanent Therefore he considers the results disappointing

W S REESE

FURTHER STUDIES ON THE USE OF FURMETHIDE IN THE TREATMENT OF GLAUCOMA E U OWENS and A C WOODS, *Am J Ophth* 29: 447 (April) 1946

Owens and Woods conclude that furmethide (furfuryl trimethyl ammonium iodide) is a valuable drug in the treatment of glaucoma, especially the severer forms, a 10 per cent solution being more effective than 20 per cent mecholyl chloride and 5 per cent neostigmine methyl sulfate in cases of late primary glaucoma and in those cases of primary glaucoma in which the previous use of other miotics has failed. Systemic reactions are rare, and no evidence of local sensitivity or irritation has been noted.

W S REESE

GLAUCOMA AND CHOKED DISK L ECTORS and C BIGAUX-VAN BOVEN, *Ophthalmologica* 108:113 (Sept) 1944

The authors give the various factors responsible for the production of choked disk as follows (1) increase of the cerebrospinal fluid pressure, (2) increase of the intracranial venous pressure, (3) increase of the general arterial blood pressure and (4) decrease of the intraocular pressure. In the cases reported a choked disk due to increased cerebrospinal fluid pressure disappeared as the intraocular pressure became elevated.

F. H ADLER

### Hygiene, Sociology, Education and History

OPHTHALMIC PROBLEMS AND VISUAL STANDARDS IN INDUSTRY J MINTON, *Brit J Ophth* 30:298 (May) 1946

The following grades of vision are suggested in allocating applicants for employment, whether juvenile or not, to various occupations.

Grade 1 To this group belong all persons possessing 6/6 or 6/9 vision in each eye and also those having 6/6 vision in one eye and not less than 6/36 vision in the other eye. Persons in this group are fit for all occupations.

Grade 2 Persons having visual acuity of not less than 6/12 in each eye and also those having 6/12 vision in one eye and not less than 6/36 vision in the other eye. Working people with grade 2 vision are fit for all industrial occupations except for the very close work essential in the manufacture and inspection, for example, of radio valves and electric lamps, in certain silk yarns trades and in a few others. Grade 2 vision is sufficient for all clerical work, the engineering industry and the driving of vehicles.

Grade 3 In this group are all the one-eyed persons who have 6/6, 6/9 or 6/12 vision in the good eye and less than 6/36 vision in the other eye, or who have one blind eye. The one-eyed persons with 6/6 in the good eye are fit for all occupations, even for those which require fine, close work. The one-eyed persons who have 6/9 or 6/12 vision can be engaged in most trades and industries. Certain occupations, such as coal mining, and certain operations in the engineering trades, such as hammering, chipping, turning and milling, present a greater danger of injury to the eyes. It is therefore suggested that one-eyed workers should not be engaged in coal mining or in any of the aforementioned engineering operations.

Grade 4 To this group belong the working people who have 6/24 vision in each eye, or who have 6/24 in one eye and 6/36 in the other eye. People with grade 4 vision can be employed in all outdoor occupations, building trades, carpentry, dock labor, portering and many similar trades.

Grade 5 To this group belong the blind and partially blind and can include all persons with less than 6/36 vision in either eye. It is pointed out that many young men with a latent hyperopia of 2 or 3 D have 6/6 vision without glasses on entering the railway service, as required, but at the age of 40 the latent hyperopia becomes manifest and vision drops to 6/18. When the man is reexamined at this age, the required 6/6 vision can be attained only with glasses, and promotion is refused.

W ZENTMAYER

ARABIAN OPHTHALMOLOGY W B I POLLOCK, Brit J Ophth 30: 445 (Aug ) 1946

This paper on the Arab school of ophthalmology was read in the summer series of lectures in the department of ophthalmology, University of Glasgow. It does not lend itself to abstraction. Pollock states, however, that it may be said that the Arabic books on ophthalmology were mainly taken from the Greek, but Hirschberg points out that the Greeks had no good ophthalmologic textbook except that of Alexandros, and he was never mentioned by the Arabians. What they took from the Greeks they had to select according to their own plan. They treated the Greek text with the greatest respect, discussed every word and then added their own observations, and they were often accurate in symptomatology, diagnosis and treatment.

W ZENTMAYER

### Injuries

SUPERFICIAL "BURNS" OF SKIN AND EYES FROM SCATTERED CATHODE RAYS L L ROBBINS, J C AUB, O COPE, D G COGAN, J L LANGOHR, R W CLOUD and O E MERRILL, Radiology 46: 1 (Jan ) 1946

Robbins and his associates report injuries received by 6 men in the department of radiology at the Massachusetts General Hospital as a result of a few seconds' exposure to scattered electrons from a 1,200 kilovolt electrostatic generator. The exact dosage could not be determined but was probably between 1,000 and 2,000 "tissue roentgens." The lesions had the unusual characteristic of appearing in three phases, the last one becoming manifest approximately four weeks after the exposure, except for a mild injection of the conjunctiva in 3 men, coming on within a few hours after the exposure, no ocular signs occurred during the first two phases of reaction. Severe ocular signs developed in 1 man in the tertiary phase and consisted of punctate epithelial lesions, accompanied with severe photophobia, lacrimation and a foreign body sensation. Cutaneous lesions elsewhere were present.

J A M A (W ZENTMAYER).

ELECTRIC OPHTHALMIA L K WOODWARD JR, U S Nav M Bull  
46:247 (Feb) 1946

Woodward observed 47 patients with flash burn of the eyes, or electric ophthalmia, on a repair ship. The greater number were men working in the immediate vicinity of the welders, and all these men had momentarily removed their goggles at the time an arc was struck or did not use goggles while at work. The symptoms were principally mild to severe injection of the conjunctiva and, more especially, an episcleral injection. Five men had considerable edema of the eyelids. In 6 men there was evidence of pseudopterygium with accompanying injection. Superficial ulceration of the cornea was present in 2 men. Treatment consisted in irrigation of the eye with mild boric acid solution and instillation of a solution containing tetracaine hydrochloride and neo-syneprine hydrochloride. In many instances an ointment containing 2 per cent butacaine sulfate also was employed. Relief was obtained, especially when there was edema of the lids, by application of cool boric acid compresses. The response to therapy was prompt. About one third of the patients were removed from duty for a period of twenty-four hours.

J A M. A (W ZENTMAYER)

### Operations

IRIDENCELSIS—A MODIFICATION D P SMITH, Brit J Ophth 30:  
589 (Oct) 1946

The method Smith adopts in performing iridencleisis is described. The pressure of the vitreous is first lowered by a scleral puncture made with a Graefe knife 45 degrees to the temporal side of the vertical meridian and 6 mm from the limbus. On entering the sclera with a narrow, parallel-sided keratome, an incision is made similar to that for a preliminary iridectomy. With an iris hook the iris is drawn into one angle of the wound and snipped off. By stroking the wound from the opposite end, one pillar of the loop is freed, so that it slips back into the anterior chamber, leaving the other incarcerated. A scissors cut is then made in the conjunctiva 5 mm above and parallel to (and rather longer than) the keratome incision. The conjunctiva is then undermined with two pairs of fine forceps, and the lips of the conjunctiva over the keratome incision are then pinched together, they adhere because the elastic pull has been abolished by the conjunctival incision. This wound serves the added purpose of providing a temporary outlet for the aqueous, so that the lower conjunctival wound is not forced open again but has time to unite. The article is illustrated.

W ZENTMAYER

### Orbit, Eyeball and Accessory Sinuses

THE SCLERAL-RESECTION (EYEBALL-SHORTENING) OPERATION D.  
VAIL, Am J Ophth 29:785 (July) 1946

Vail opens this de Schweinitz Lecture with praise for the work done by de Schweinitz as a medical officer during World War I. He then reviews the history, technic and case records of scleral resection and reports a case of bilateral scleral equatorial staphyloma and detached retina cured by scleral resection.

W S REESE.



PROPTOSIS—DIFFERENTIAL DIAGNOSIS F MASSOUD, Brit J Ophth  
30:622 (Oct ) 1946

It is not possible to make a satisfactory abstract of an article of this nature. Massoud gives the following summary of the classification of proptosis employed and the conditions which may be encountered in each category

*Apparent*—Globe not displaced, high myopia, buphthalmos, megalophthalmos, staphyloma, paralysis of the seventh nerve

*Due to Congenital Anomaly*—Arrested development, premature ossification, shallow orbit, cranial hernias appearing as tumor masses, vascular, nervous, mixed

*Due to Traumatic Injury*—Intracranial—tear of internal carotid artery or cavernous sinus, intraorbital—aneurysm of the ophthalmic artery, extraorbital—tear of carotid artery or jugular vein, late effect—proliferation

*Due to Inflammatory Process*—Acute—from injury or extension, abscess, cellulitis, thrombophlebitis, anthrax, subacute—mucocoele, retrobulbar, subperiosteal, chronic—tuberculous, syphilitic, actinomycotic, hyatid, etc, late effect—from obstruction

*Due to New Growth*—Intracranial—meningioma, osteoma, oral and nasopharyngeal—myxoma, chondroma, plasmoma, osteoma, orbital—cavernous angioma, osteoma, lacrimal cylindroma, carcinoma, ocular—from optic nerve and sheath, choroid, retina, metastatic—sarcoma, carcinoma

*Due to Systemic Condition*—Sympathetic—exophthalmic goiter, endocrinal disturbance—malignant exophthalmos, metabolic—scurvy, rickets, hemophilia, hyperplastic—leukemias, xanthomatosis, Paget's disease (osteitis deformans)

Methods of diagnosis include general examination, history taking, transillumination, roentgenographic examinations, tests and cytologic studies of the blood, special laboratory tests, medical and surgical procedures

W ZENTMAYER

### Pharmacology

A CLINICAL TRIAL OF A SYNTHETIC MYDRIATIC (DIMETHYLAMINO-ETHYL BENZYLATE ETHOCHLORIDE [BENZILYLOXYETHYL DI-METHYLETHYL AMMONIUM CHLORIDE]) W J B RIDDELL, Brit J Ophth 30:1 (Jan ) 1946

This substance (benzilyloxyethyl di-methylethyl ammonium chloride), referred to as E3, in 1 per cent aqueous solution was compared with a 1 per cent solution of atropine sulfate and a solution of 1 per cent homatropine hydrobromide and 2 per cent cocaine. The impression was obtained that the new substance is probably an efficient substitute for homatropine both as a mydriatic and as a cycloplegic.

The action of E3 in 1 per cent solution is neither so rapid nor so prolonged as that of atropine. It reaches a maximum in an hour, and the effect commences to fall off in five or six hours. No cutaneous irritation was found in subjects known to have sensitivity. No changes were observed in the corneal epithelium.

W ZENTMAYER

A NEW SYNTHETIC MYDRIATIC I MANN, Brit J Ophth 30:8 (Jan) 1946

Mann found that the synthetic mydriatic known as E 3 (benzilyloxyethyl di-methylethyl ammonium chloride) can be used for diagnostic and refractive purposes in the same way as atropine. Its action is more easily reversed by physostigmine than is that of atropine, but in old people it is not so safe as is homatropine. It appears to lie between atropine and homatropine in its strength of action on normal eyes. None of the patients made any complaint of discomfort from its use.

This synthetic mydriatic is nonirritating and nontoxic. It is in all respects suitable as a substitute for atropine, though it may have to be used more frequently.

W ZENTMAYER

### Refraction and Accommodation

THE EFFECT OF SUNLIGHT ON DARK ADAPTATION B CLARK, M L JOHNSON and R E DREHER, Am J Ophth 29:828 (July) 1946

The authors found that persons exposed to sunlight for three to four hours a day over a period of two weeks showed a marked elevation of the night visual threshold immediately after exposure. The degree of elevation persisting overnight is sufficient to cause approximately a 50 per cent loss in night visual efficiency. These effects are temporary.

W S REESE

UNAIDED VISUAL ACUITIES CORRELATED WITH REFRACTIVE ERRORS M H PINCUS, Am J Ophth 29:853 (July) 1946

The physical examination records of 45,206 men and women as well as 7,482 refraction records were reviewed for this study, which was designed to correlate the unaided visual acuity with the different refractive errors. It was undertaken to supply the need of a simple method to detect malingerers.

W S REESE

### Retina and Optic Nerve

RADON SEEDS IN THE TREATMENT OF GLIOMA RETINAE S PHILPS, Tr Ophth Soc U Kingdom 64:107, 1944

A boy 5 months old had the left eye removed for glioma of the retina. The right eye was normal. Four and one-half years later a glioma was noted in the upper nasal quadrant of the right eye. Permission for removal of the eye was refused by the parents, as an older brother had bilateral enucleation for glioma of the retina and died of intracranial extension. A 3 millicurie radon seed was inserted in the growth and removed ten days later. The growth "shrank away." On two subsequent occasions reapplication of radon seeds was made for what was thought to be recurrence of the growth at the site of the original tumor. Three years later the eye was free from growth and visual acuity equaled 6/12. There were macular changes resembling retinitis circinata. At the age of 19 vision was somewhat reduced, owing to irradiation cataract. The author believes that what was supposed to be recurrence was in fact reparative fibrous tissue and that therefore the subsequent irradiations

were unnecessary. In the second case the diagnosis was that of bilateral glioma retinae in a boy aged 8 months. The left eye was almost full of growth and was removed. In the right eye the growth was globular and measured 6 disk diameters in each direction. A 2.5 millicurie radon seed was introduced into the center of the growth. At the time of the report, three years and four months after irradiation, all that remained of the growth was a small, mulberry-like nodule, which had remained unchanged for two years. It seems unlikely that there remained any active growth in the eye. Visual acuity was about 6/12.

W ZENTMAYER

THE OPTIC NERVE AND THE MESSAGES IT TRANSMITS. A. MAGITOT,  
Ann d'ocul 179: 24 (Jan) 1946

The introduction to this article deals with a brief anatomic description of the optic nerve and how it differs from other sensory nerves in various ways, such as in not having a sheath of Schwann. This is followed by a general discussion of the physiologic properties concerned with the transmission of impulses in sensory nerves. The author discusses such topics as summation, the all or none law, amplitude and the latent period. The research work on the chronaxia in man and animals is reviewed.

The objective measurement of the visual response is fully covered, especially the work of Hartline and Granit. Hartline's work on single nerve fibers in the frog retina, in which it is shown that three types of fibers are present, and Granit's work on color vision are applied to present day concepts of vision. The author feels that from anatomic and physiologic studies one must admit that the optic nerve contains both visual and pupillomotor fibers.

In conclusion, an attempt is made to correlate the clinical findings in diseases of the optic nerve with the physiologic knowledge of its function. As an example, the author cites the controversy concerning the site of intoxication in tobacco amblyopia. In this condition the chronaxia is normal, placing the lesion in the visual cells, the rods or cones. (with involvement of the bipolar cells the chronaxia has been shown to be abnormal). Because the centrocecal scotoma is for red, the lesion can be still more accurately localized in those cones that Granit considers to be concerned with the appreciation of red.

This article should be read in full by those interested in the physiology of vision.

P. R. McDONALD

EXUDATIVE RETINITIS OF COATS. REPORT OF A CASE. J. P. JOLY,  
Arch d'opht 6: 46, 1946

A youth aged 19 had a complete cure of exudative retinitis, occurring either spontaneously or as the result of intravenous injections of salicylates. The patient had all the classic signs of the disease described by Coats in 1908. His general health was perfect, tuberculosis could not be demonstrated. There was coexisting cyclitis. The case is presented because of the relatively favorable outcome in a condition for which the prognosis is usually bad.

S. B. MARLOW

RETINAL CYSTS O KURZ, *Ophthalmologica* 107:233 (May-June) 1944

The author divides retinal cysts into two types (1) those associated with a retinal detachment, and (2) those with no associated detachment. This differentiation is based on the ordinary ophthalmoscopic examination, but the author points out that in some cases a detachment of the macular region may be present which can be detected only by means of examination of the fundus with the slit lamp (the author used the Goldmann apparatus for this purpose).

Two cases are described in which cysts occurred with a characteristic picture of detachment below and tears in the ora serrata. Cysts of this type occur frequently in the eyes of youthful (not myopic) patients. The detachment is usually in the lower temporal portion of the retina, shows little tendency to progression and exhibits an inclination to spontaneous delimitation through the formation of a choroidal barrier. The disease is frequently latent for a long period, without the patient's knowledge. The operative prognosis is generally favorable.

The condition frequently occurs symmetrically in the two eyes and occasionally is familial. Two cases of this type are described, and the pathogenesis of cyst formation is discussed. Two other cases of uncomplicated cyst formation are reported. The diagnoses in these cases were idiopathic cyst and cyst following choroiditis. Their pathogenesis is also discussed.

F H ADLER

SYMPTOM COMPLEX OF CHORIORETINITIS CENTRALIS SEROSA (KITAHARA) R BRUCKNER and N H FIELD, *Ophthalmologica* 109:281 (June) 1945

Three cases of this disease are reported. The characteristic signs are described.

1 Ophthalmoscopic Findings. There is a flat detachment in the macula, which is made evident by a sharply limited ringlike reflex. At the beginning this area may be somewhat deeper colored than normal. The area affected is usually circular, but it may be elliptic. After three to five weeks' duration, numerous small yellowish points appear within this area, and after healing only a few lightly pigmented spots may remain.

2 Subjective Symptoms. These consist of a relative, more or less intensive, positive scotoma, together with alterations in the color sense. Occasionally, micropsia and metamorphopsia may be present, but the lowering of the visual acuity is usually slight. In general, the visual acuity returns to normal, even after a duration of several months. In some cases the hyperopia undergoes a transitory increase.

3 Recurrences. These are frequent. Kitahara reported cases in which there were fourteen recurrences over a period of three years. As a rule, the recurrences affect the same part of the retina. The author believes that the primary changes are localized in the choroid and may be the result of a nonbacterial allergic reaction. He suggests that the tubercle bacillus may play a role. He also considers the possibility that the disease is a vascular disturbance of nervous origin. He points out the difficulties in making the diagnosis early and suggests that the following technics, if employed, will enable one to make

- a diagnosis earlier than usual 1 Focal illumination of the fundus  
 2 Entopic proof of a positive scotoma by illumination through the sclera  
 (which he refers to as "disscleral transillumination") This succeeds  
 in eliciting a scotoma when the patient is not spontaneously aware of it  
 3 Entopic proof of the detachment of the retina by disscleral illumination  
 The article contains a very good colored plate of the eyegrounds

F H ADLER

THE RELATION OF PERIPHLEBITIS RETINAE AND RECURRENT JUVENILE  
 VITREOUS HEMORRHAGES TO THROMBOANGIITIS OBLITERANS  
 (BUERGER'S DISEASE) A E SCHMID, *Ophthalmologica* 110 259  
 (Nov-Dec) 1945

Eighty-six patients with thromboangitis obliterans and 25 patients who had periphlebitis retinae and recurrent hemorrhages in the vitreous were examined in order to determine whether there was any relationship between these two conditions, as claimed by Marchesani (*Arch f Augenh* 109:124, 1935) Schmid could find no proof that these two conditions are in any way related He believes that periphlebitis retinae is due almost exclusively to tuberculosis

F H ADLER

### Tumors

IMPORTANCE OF EXAMINATION OF THE NERVE SHEATH IN CASES OF  
 TUMOR OF THE OPTIC NERVE MONBRUN, G OFFRET and  
 J GUILLAUME, *Arch d'oph* 5:8, 1945

The authors point out that in histologic descriptions of tumors of the optic nerve the sheath is often passed over without notice or is insufficiently examined They described a case in which operation was performed in 1937 and present a histologic study with photomicrographs of the tumor In the nerve sheath proliferation of the glial tissue was evident A second, much more complex, case was described The authors review some of the reports in the literature They try to show, first, that certain unexplained facts about tumors of the optic nerve become clear when gliosis or gliomatosis of the perineurium is considered Second, the data which they have accumulated favor the idea of a congenital dysplasia in certain of these tumors As the result of their histologic studies, they believe that when a tumor of the optic nerve is examined the whole sheath should be carefully studied

S B MARLOW

ANGIOMAS OF THE ORBIT G RENARD and G OFFRET, *Arch d'oph*  
 6:284, 1946

This is an anatomic and pathologic study of angiomas of the orbit Anatomic cavernous angioma is the most frequent form It is a circumscribed condition and not infrequently occurs within the muscle cone A number of cases are presented, with histologic drawings, and an extensive histologic study is reported In addition to the cavernous angioma, angioma lipoma and hemolymphatic angioma are discussed In conclusion the authors state that care must be exercised in the classification of angiomas of the orbit As a matter of fact, only a

small number of them have been accurately classified. It is not necessary to introduce a new terminology. A bibliography is appended.

S B MARLOW

PLASMOMA OF THE CONJUNCTIVA H CORTES, Arch Soc oftal hispano-am 4: 238 (April) 1945

A woman aged 21 presented partial ptosis of the right upper lid. The skin of the lid was raised, and there was ectropion of the inner two thirds. The exposed conjunctiva showed a fleshy mass with vegetations of a pink color. On eversion of the lid, a large, fleshy, papillomatous mass was observed. The mass was divided in three formations by deep folds. Its color resembled somewhat that of vernal conjunctivitis. The lower lid presented folliculosis. There were no subjective symptoms. The left eye was normal.

Histopathologic examination showed that the mass was chiefly formed of newly formed tissue rich in plasmocytes with many lymphocytes and polymorphonuclear leukocytes in nodular formations. The diagnosis of trachoma was ruled out. The tumor was treated by excision with the diathermy loop.

The article contains numerous photographs and photomicrographs.

H F CARRASQUILLO

A CASE OF EPITHELIOMA OF THE LACRIMAL GLAND A MOREU and E FORNES, Arch Soc oftal hispano-am 6: 59 (Jan) 1946

A case of epithelioma of the lacrimal gland is reported. The tumor is extremely rare. A woman aged 46 gave a history of her trouble having begun when she was 16 years of age. Very insidiously the right eye began to proptose and diplopia developed. At the time of examination she presented a hard, freely movable, bilobulated mass in the region of the lacrimal gland. There was paralysis of the sixth nerve. Operation was performed for a benign neoplasm of the gland, but histologic examination revealed an epithelioma. Photomicrographs are shown.

H F CARRASQUILLO

NEUROMA OF THE OPTIC NERVE AFTER ENUCLEATION JEAN BABEL and MARIO VALERIO, Ophthalmologica 109: 317 (June) 1945

A man aged 40 received an injury to his left eye which necessitated its enucleation. After this persistent neuralgia developed in the left orbit, followed by a chronic inflammatory process. Surgical exploration of the orbit revealed an amputation neuroma, accompanied with a chronic inflammatory cellular infiltration. In the adherent stump of the optic nerve there was a small granuloma with giant cells. The authors believe that the neuroma originated in the ciliary nerves.

F H ADLER

#### Uvea

SEROUS CENTRAL CHOROIDITIS P BONNET, L PAUFIQUE and BONAMOUR, Arch d'opht 6: 129, 1946

The authors point out that this condition is not well known in Europe but has received especial attention in Japanese literature. The

bibliography is rich in articles under many titles, all of which probably designate cases of this disease. The authors describe the clinical picture, which begins with loss of vision and color scotomas. In the early stages vision may be improved with a convex spherical lens. The ophthalmoscopic picture is described in detail. The macula is the site of a bullous swelling, sometimes red and sometimes orange, with surrounding brilliant reflexes. This swelling may have an elevation of 3 or 4 D or more, and its walls are sometimes rather transparent. In the presence of such a large lesion the visual disturbance is extreme. The condition usually becomes bilateral sooner or later. There are cases of the extramacular form of the disease. In the differential diagnosis cysticercosis must be taken into consideration. The cause is not definitely known, although there is evidence that tuberculosis is an important factor. The authors have never found that syphilis was the cause. They report observations on 7 cases, with drawings and photographs.

S B MARLOW

TWO CASES OF UVEITIS ASSOCIATED WITH ALOPECIA, VITILIGO, DYSACUSIA AND POLIOSIS (VOGT-KOYANAGI SYNDROME) S BARRENECHEA and R CONTARDO, *Arch chilena de oftal* 2:5 (Sept-Oct) 1944

Two cases of the Vogt-Koyanagi syndrome are reported in women aged 44 and 26, respectively. In the first case vision was reduced to counting of fingers and perception of hand movements and in the other to perception of light. In 1 case all the cardinal symptoms of the condition were present, and in the other only dysacusia was missing. Both patients had evidences of infectious processes at the apex of the teeth. They were treated similarly by extraction of the diseased teeth and with vitamins (vitamin B complex, ascorbic acid, nicotinic acid).

The ultimate results of the treatment were as follows. In the first case vision after eleven months was limited to counting fingers at 1 meter in the right eye and was 2/10 in the left eye. In the second case, in which complicated cataracts were extracted, vision after two years was 4/10 in each eye.

H F CARRASQUILLO

### Vision

PROBLEM OF NIGHT VISION K KEKCHYEV, *Am Rev Soviet Med* 1:300 (April) 1944

Kekcheyev points out that methods developed in prewar days for changing visual thresholds by application of caffeine or strychnine had been of laboratory interest only. The literature offered a few suggestions for altering the threshold of certain sensory organs by stimulating other sensory organs. It was established that the stimulation of any external sensory organ (hearing, smell, touch and taste) may augment or diminish the thresholds of visual perception. The author showed that a change in the acuity of night vision produced by stimulation of other sensory organs was not an isolated process but was part of a diffuse autonomic reflex. The thresholds of night vision varied with the pulse rate, the blood pressure level, respiration and electrical resistance of the skin to direct current. Not all stimuli were equally effective in raising the threshold.

of night vision Taste, cold and proprioceptive (moderate effort) stimuli were chosen as being the most practical and convenient During drowsiness the sensitivity of the eye shows a sharp decrease The application of cold not only restores vision and hearing but terminates drowsiness as well By application of taste, cold and proprioceptive stimuli the period of dark adaptation was reduced to from five to six minutes The acceleration of the dark adaptation period is of great practical importance under battle conditions—for instance, for night fliers, who must discern the enemy bomber in the gloom of the night, in so-called dazzling of the eyes by a searchlight, rocket or the flash of tracer bullets Experiments carried out in 1943 in the author's laboratory in Moscow showed that the use of red eyeglasses five to ten minutes after the white light has begun to act promptly restored vision to its normal threshold and occasionally intensified it Thus, the same white light which had previously destroyed the sensitivity of the dark-adapted eye increased that sensitivity when filtered through red glasses

J A M A (W ZENTMAYER)

RELATIONSHIP OF VISUAL ACUITY TO THRESHOLD OF BRIGHTNESS PERCEPTION J TEN DOESSCHATE, *Ophthalmologica* 108:187 (Oct-Nov) 1944

If two stimuli affect a sense organ with intensities  $B$  and  $B'$ , respectively, the subject will be able to discriminate between the two if the difference is above the threshold level This threshold level is known as  $\Delta B$  In the present series of experiments, in comparing two brightnesses,  $B$  and  $B'$ , the threshold,  $\Delta B$ , is determined under such conditions that the brightness  $B$  fills the whole visual field, while brightness  $B'$  is observed in a circular test field at a visual angle,  $g$ , with foveal fixation Under these conditions, the author has examined the manner in which  $\frac{B}{\Delta B}$  depends on (1) the brightness of  $B$ , (2) the visual angle,  $g$ , and (3) the state of adaptation of the eye The results of these experiments are discussed and compared with those of other investigators It was shown that the visual acuity,  $B$ , and  $\frac{B}{\Delta B}$  depend in an identical way on the brightness The results of these experiments are in accordance with the recent calculations of de Vries (*Physica* 10: 553, 1943), which take into account the statistical fluctuations in the number of light quanta which are "hitting" the various retinal regions

F H ADLER

### Vitreous

SACULAR PROLAPSE OF THE VITREOUS BODY R A POIRIER, *Am J Ophth* 29:845 (July) 1946

Poirier reports the case of a white man who had an injury of the right eye in 1918, with later development of a dislocated lens The eye was divergent and the lens partly absorbed, and there was saccular herniation of the vitreous through the pupil Because of increased tension, capsular remnants were removed through a keratome incision, accompanied with loss of vitreous Recovery was uneventful, and vision of 6/7 was obtained with lenses

W S REESE



INTRAVITREAL INJECTION OF PENICILLIN IN A CASE OF INCIPIENT ABSCESS OF THE VITREOUS, FOLLOWING AN EXTRACAPSULAR CATARACT EXTRACTION A FEIGENBAUM and W KORNBLUTH, *Ophthalmologica* 110:300 (Nov-Dec) 1945

A case of an abscess in the vitreous following extracapsular cataract extraction and its complete cure by intravitreal injection of penicillin is described. The adjuvant value of subconjunctival injections in overcoming the infective process is stressed. The probability of synergistic action from the simultaneous use of sulfadiazine is mentioned.

F H ADLER

Therapeutics

CONTROL OF EXPERIMENTAL ANTERIOR-CHAMBER INFECTIONS WITH SYSTEMIC PENICILLIN THERAPY A E TOWN, F C FRISBEE and J G WISDA, *Am J Ophth* 29:341 (March) 1946

Town, Frisbee and Wisda were able to control experimental infections of the anterior chamber of rabbits with massive doses of penicillin given intramuscularly, and in the absence of injury to the lens normal function of the eye was restored.

W S REESE

THE INTRAOCULAR USE OF PENICILLIN I MANN, *Brit J Ophth* 30. 134 (March) 1946

The subject is discussed under two headings: experiments on rabbits, and the use of penicillin intraocularly in man.

The result of the injection of various solutions of penicillin into the anterior chamber is to produce a reactive aseptic anterior uveitis of varying severity. Even 100 per cent pure penicillin produces some reaction. When the solution was injected into the vitreous, the immediate effect was the formation of a localized opacity in the vitreous, with the track of the needle leading up to it. From the fifth to the seventh day a severe retinochoroiditis accompanied by various vascular changes occurred, at the same time the nerve head became swollen, and in most cases there was the suggestion of thrombosis of the central vein. The pathologic observations at the end of two months in a case of a severe reaction are given. The condition would seem to be a most complete neuroretinal degeneration, followed by fibrosis and accompanied by thickening and fibrosis of the choroid. In all the eyes tested with pure penicillin the course of the events was much milder and none of the eyes became blind.

It appears, therefore, that the serious results obtained with the impure samples were due not to the penicillin itself but to something else, unidentified, which produced the intense pathologic change. In order to decide whether intraocular injection of penicillin was likely to be of therapeutic value, an endeavor was made to find out how long it remained in the eye after one or two injections into the anterior chamber. It would appear that strong inhibitory action can be expected for at least six hours but that persistence for much longer is unlikely. No evidence was found that an aqueous altered in constitution would retain penicillin longer.

The clinical notes in cases of perforating injuries of the eyeball and a case of corneal ulcer with hypopyon in which penicillin was used in the anterior chamber are given

It would appear that intraocular injection of high concentrations of penicillin is justifiable in severely injured or infected eyes but that the best results are to be expected when the infection is confined to the anterior segment of the eye and the penicillin does not come in contact with the vitreous. Further work with purer solutions might give better results in these cases

W ZENTMAYER

PENICILLIN IN OPHTHALMOLOGY THE BACTERIOLOGICAL, EXPERIMENTAL, AND CLINICAL EVIDENCE OF ITS VALUE, INCLUDING A PERSONAL SERIES OF 125 CLINICAL CASES C A BROWN, Brit J Ophth 30:146 (March) 1946

Brown reviews the literature on the bacteriologic, experimental and clinical evidence of the value of penicillin in ophthalmology and reports on his experience with treatment in 125 clinical cases. Penicillin is established as the most effective therapeutic agent for acute mucopurulent conjunctivitis, as of real value in the treatment of acute keratoconjunctivitis and of great value in preventing secondary infections by early application after injury and, if infection has supervened, in sterilizing the conjunctival sac while the injured tissues recover. The value of penicillin with traumatic infection of the anterior segment is not yet established, but if an obviously septic wound is present it is definitely indicated. Penicillin is of value in the treatment of deep infections of the eye of bacterial origin. Three cases of sensitization to penicillin are described.

W ZENTMAYER

LOCAL TREATMENT OF INTRABULBAR INFECTIONS 6 TREATMENT OF STAPHYLOCOCCUS PANOPHTHALMIA BY INTRABULBAR INJECTION OF PENICILLIN G ROENNE, Brit J Ophth 30:405 (July) 1946

For the present it is justifiable to assume that in penicillin ophthalmologists possess the best weapon so far at their disposal for combating intraocular infections and that local treatment offers a number of advantages not possible with general treatment, viz (1) a bactericidal concentration of penicillin is maintained for a long period, sixteen to twenty-four hours, (2) only small quantities of penicillin are necessary, and (3) as Leopold and Struble and Bellows have shown, general treatment with penicillin does not lead to any demonstrable concentration in the vitreous, or at any rate in only very small quantities. Roenne draws the following conclusions: 1 In therapeutic concentrations of 100 to 500 Oxford units the injection of penicillin into the vitreous body is practically harmless. 2 Intravitreal treatment of infections of the vitreous body with penicillin is extraordinarily effective as compared with other forms of application and other substances. 3 The effectivity of the treatment is directly proportional to the concentration of penicillin. 4 Within fairly wide limits the results of the treatment are dependent only on the number of bacteria in the eye, and not on the interval between inoculation and treatment. 5 The method employed provides indirect information as to the velocity of the absorption of the penicillin from the vitreous body.

The values found agree very well with the results gained by direct bioanalysis 6 The velocity of the absorption of penicillin from the vitreous body is expressed by the halving time, about six hours 7 The function  $\log$  bacteria concentration- $\log$  therapeutic penicillin concentration is of first degree 8 For intrabulbar, especially intravitreal, inflammation, the injection of penicillin into the vitreous body is the best therapy at the moment

W ZENTMAYER

PENICILLIN IN TREATMENT OF COMMON EXTERNAL EYE INFECTIONS  
JOSEPH MINTON, Brit M J 2:324 (Sept 7) 1946

The author found that in treatment of external ocular infections in children penicillin was of advantage in blepharitis and conjunctivitis The drug was used in the form of an ointment with the former and in the form of drops, 1,000 or 2,000 units per cubic centimeter, with the latter In treatment of external infections in adults satisfactory results were obtained with the same remedy The drops were used four times a day, and the infections cleared up rapidly If a corneal ulceration was present, the same treatment was given combined with atropine and hot compresses Dendritic ulcers were not benefited and were treated with 30 per cent drops of sulfacetimide, atropine and hot compresses In a number of adults, after use of penicillin in the form of drops or ointment, the skin of the lids became red and edematous, and the reaction often extended to the skin of the cheek and forehead This reaction was not due to the composition of the ointment but was produced by the penicillin The author found that the industrial ocular injuries were best treated with drops of a penicillin solution

The life of a penicillin solution is limited, as penicillin is hydrolyzed in the presence of moisture The stability of penicillin is also affected by the  $p_H$  of the solution The stability is also influenced by the temperature Investigation of the actual life of a penicillin solution shows that at room temperature the solution retains between 90 and 100 per cent of the original potency for eight days On the fourteenth day the potency had fallen to 75 per cent The  $p_H$  of the solution also enters into the question of stability, and it is important that the  $p_H$  be as close as possible to that of tears, which is 7.2

Directions for the preparation of the drops and of the ointment are given in the article

The deterioration of penicillin in eye drops is much more active at room temperature than when the solution is kept in a refrigerator As a rule, the useful life of the solution is between two and three weeks

ARNOLD KNAPP

USE OF CIBAZOL [SULFATHIAZOLE] IN OPHTHALMOLOGY E BURKI,  
A E SCHMID and G SAUBERMANN, Ophthalmologica 106:113  
(Sept) 1943

This paper is a lengthy report on the authors' experience with sulfathiazole in various ophthalmic conditions They find that the chief indications for this form of treatment are erysipelas of the lids, ophthalmia neonatorum, serpent ulcer, catarrhal ulcer and infiltrates, tuberculosis of the eye, gonococcic iritis and intraocular infection following perforating injuries

F H ADLER

## Book Reviews

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**Medicine in the Changing Order.** Report of the New York Academy of Medicine, Committee on Medicine and the Changing Order  
Price, \$2 Pp, 240 New York Commonwealth Fund, 1947.

This little volume represents the work of a group appointed in December 1942 to study the complex problems of adequate medical care. For the purposes of research, collection of information and eventual recommendations, no less than eleven subcommittees were appointed to deal with such subjects as medical education, undergraduate and postgraduate, internships, the hospitals, administration of public health services, industrial and rural medicine, consultant services, nursing, and dentistry. As finally composed, the committee was made up of thirty-three physicians and seventeen lay persons, selected, on the one hand, from the fields of medical education and public health, and, on the other, from the ministry, the law, social welfare, the hospitals, insurance, labor and industry.

Financed by the Commonwealth Fund, the Milbank Memorial Fund and the Josiah Macy Jr. Foundation, the collected reports form an authoritative and instructive body of information on matters of public health, cost and quality of medical care, urban and rural, throughout the nation, preventive medicine, and insurance, both voluntary and compulsory. While the various suggestions and recommendations do not lend themselves readily to summary or logical analysis and critique, they do repay those who will read, mark, and inwardly digest. The present reviewer would call attention particularly to the opening chapters. One deals with the origins of present problems in American medicine before 1800 and a study of the economic, social, political and industrial factors, as well as the factors more strictly concerned with the profession and practice of medicine, including dentistry, nursing, and hospitalization. Another chapter, entitled "Medicine and the Changing Order," carries on the historical survey to recent decades, with a study of the influence of industrialism, the relation of poverty to medical care, the rise of big business and big government, the emergence of social insurance and the health of the nation.

The method and the goal of medical and public health services must be extended, with their organization and quality preserved and/or improved by effective use of adequate hospital facilities, trained professional and nonprofessional personnel and the organization and cooperation of physicians, with their education, as well as that of the public, adapted to the various needs of the community. Government aid will be required. All in all, the book is a noteworthy contribution which reflects great credit on the committee, and as a *Festschrift* comes most appropriately at a time when the parent organization, the New York Academy of Medicine, is about to celebrate its centennial anniversary—one hundred years of helpful activity in so many matters pertaining to the health of the community.

PERCY FRIDENBERG, M.D.

**Archivos de la Asociación para evitar la Ceguera en México (Archives of the Association of Prevention of Blindness in Mexico).**  
Director, Dr Luis Sánchez Bulnes, Chief Editor, Dr Daniel Silva  
Vol IV Pp 605 México, D F Secretaría de educación pública, 1946

The book brings a report of the work done in the hospital of the association in Mexico, D F, during 1946 and a description of the activities in the various departments. A variety of pictures represent the tragedy of blindness as conceived by various Mexican artists who participated in a contest held by the association on "Art and Ophthalmology."

There are, in addition, thirty-five interesting articles on ophthalmic subjects by local and American authors, of which the following two are summarized

1 Ophthalmologic Investigation in the Zone of Onchocerciasis in Chiapas, Mexico Drs M Puig Solanes, Anselmo Fonte and José Antonio Quiroz. The diagnosis of onchocerciasis was based on the presence of nodules, on the observation of parasites and on biopsies of the skin. Men are more often affected, owing to occupational habits, and the patients are mostly under 40 years of age. Ocular involvement occurs in 75 per cent of cases. The patients complain of burning, photophobia and the sensation of a foreign body in the eyes. A number of patients had entoptic vision of microfilarias. Most of the patients in the group studied had corneal lesions, which in the majority were those of superficial punctate keratitis. With the slit lamp it is possible to see filiform opacities of uniform length, straight or S shaped, which have been interpreted as remnants of the parasites. As a rule the corneal involvement is bilateral and symmetric but impairs vision very little. The involvement of the iris is characterized by a torpid process which involves mainly the posterior structures, giving origin to the classic downward deviation of the pupil and seriously affecting vision. Cases of secondary glaucoma and phthisis bulbi have also been observed.

2 Necessity of Recognition of Biastigmatism" in Fitting of Contact Lenses. Dr Manuel Marquez. The author states that the existence of biastigmatism is a daily observation, as in most of the cases, after the correction of corneal astigmatism, there is a residual astigmatism. The contact lens corrects only the corneal astigmatism and leaves unaltered the residual astigmatism. The latter is 0.25 D in most cases, though in some instances it is as high as 2 or 4 D. The author suggests the use of his procedure of subjective ophthalmometry to determine the spherical error and the corneal and residual astigmatisms. The residual astigmatism can be corrected either by incorporation of the correction in the contact lens or with ordinary glasses.

HUMBERTO ESCAPINI, M D

## CORRELATIONS BETWEEN SENSORY AND MOTOR DISTURBANCES IN CONVERGENT SQUINT

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THE IMPORTANT factor in the production of convergent comitant squint is the primary force which turns the eyes in, i e, the excessive convergence innervation. Little is known about this in the majority of cases of squint. In only one group is one thoroughly cognizant of the manner in which an abnormal convergence stimulus is produced and how it causes squint. This is the group in which the convergence is due to excessive hypermetropia in early childhood. There is good reason to believe, as has been pointed out in previous papers,<sup>1</sup> that all the other forms of squint except those which are paralytic in origin are due to a similar increase in convergence tone, however ignorant one may be as to the manner or cause of its origin.

It is the purpose of this paper to consider the sensory relationships found in all types of convergent squint and to determine the correlations between the sensory abnormalities and the motor disabilities in the hope that some light may be thrown on the source of this excessive convergence.

### VARIOUS SENSORIAL RELATIONSHIPS FOUND IN SQUINT

When a subject's visual axes do not coincide, it means that he does not use his eyes together under ordinary conditions. There is one exception to this, which will be discussed later. But under appropriate test conditions it may be shown that a latent form of binocular vision exists in most cases.

Address delivered before the Ophthalmic Club, Philadelphia, Dec 4, 1945

From the Department of Ophthalmology, Hospital of the University of Pennsylvania

1 Adler, F H. Pathologic Physiology of Convergent Strabismus. Motor Aspects of Nonaccommodational Type, *Arch Ophth* 33:362 (May) 1945, Effect of Anoxia on Heterophoria and Its Analogy with Convergent Concomitant Squint, *ibid* 34:227 (Sept) 1945

Travers<sup>2</sup> classified binocular vision as follows

Normal Development	Simultaneous Perception	Abnormal Development
Normal correspondence		Abnormal correspondence
True fusion		
Stereoscopic vision		

Cases of squint are divided therefore into two groups, providing the patient is capable of simultaneous perception

1 *Cases with Normal Correspondence*—By normal correspondence is meant that the macula of the squinting eye retains the same spatial projection as the macula of the nonsquinting eye. Both have the "straight-ahead" visual direction in spite of the deviation of the squinting eye from the primary position. Normal correspondence is present, therefore, when a separate image is made to fall on each macula simultaneously, and the subject sees these two images superimposed as though they came from the same point in space as that of the image falling on the macula of the nonsquinting eye.

2 *Cases with Anomalous Correspondence*—In these cases the macula of the squinting eye does not have the same spatial projection as the macula of the fixing eye. Instead some part of the nasal area of the squinting eye has a common spatial projection with the macula of the fixing eye. There are three varieties of anomalous correspondence, depending on which portion of the nasal area corresponds in directional value to the fixing macula. In one type the fixing macula is associated with that part of the retina of the squinting eye on which the image customarily falls, and the projection of these two images in space is the same. This type is called harmonious. It is found infrequently, and it is the only type in which some form of binocular vision occurs under normal conditions. In the second type the macula of the fixing eye is associated with a point on the retina of the squinting eye between its macula and the point where the image customarily falls. This type is called unharmonious. The third, and most frequently found, type may be considered as a state without functional correspondence, since suppression of the nasal area of the squinting eye is so widespread that no particular area of it is found to correspond directionally with the fixing macula. This type may be considered comparable to the other types, differing only in the amount of suppression involved.

#### MATERIAL AND METHODS

One hundred and seventy-five private cases form the basis of this study. All the patients were examined with the synoptophore before treatment was instituted and were followed for their final sensorial results.

<sup>2</sup> Travers, T. aB. Suppression of Vision in Squint and Its Association with Retinal Correspondence and Amblyopia, *Brit J Ophth* 22: 577 (Oct) 1938.

after the squint was considered to have been cured as nearly as possible, whether by operation, glasses or orthoptic training or a combination of these

## OBSERVATIONS

Table 1 shows the percentage of each type of correspondence found in our cases taken as a whole

In table 2, the cases have been grouped according to cause of squint. The first column shows the distribution

*Paralytic Squint*—Paralysis of one or more muscles could be determined with certainty in 31 out of 172 cases, or in 18 per cent. Incomitance in the angle of squint is a definite sign of paralysis, but, according

TABLE 1—*Percentage Incidence of Types of Correspondence in a Series of 175 Cases*

Correspondence Cases	Number	Per Cent	Number	Per Cent
Normal	64	36		
Anomalous	111	64		
(a) Harmonious			5	5
(b) Unharmonious			17	15
(c) Suppression			89	80
Total	175	100	111	100

TABLE 2—*Distribution of Cases of Convergent Squint According to Cause*

Causal Factor	Series of Cases		Correspondence			
			Normal		Anomalous	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
Paralytic	31	18	14	15	17	55
Purely accommodative	33	19	30	91	3	9
Accommodative element	35	21	7	20	28	80
Undetermined	73	42	13	18	60	82

to Chavasse, incomitance may be lost if the muscle recovers sufficiently and a comitant angle of squint remain. Chavasse<sup>3</sup> explained this comitant element by the fact that during the paralytic stage the antagonist of the paralyzed muscle may become shortened by contracture and remain in this shortened state. He inferred that most squints which are not accommodative belong in this category. However, comitance is not found in cases of paralysis of an ocular muscle occurring in later life, and, to our knowledge, no one has ever observed any of the children with comitant squint go through the stage of incomitance and acquire comitance as the paralyzed muscle recovered.

3 Worth, C. A. *Worth's Squint, or the Binocular Reflexes and the Treatment of Strabismus*, edited by F. B. Chavasse, ed. 7, Philadelphia, The Blakiston Company, 1939.



It is true that paralysis of an ocular muscle may recover to the extent that the eye can be rotated fully in the direction of action of the paralyzed muscle, but one can always recognize the underlying weakness of this muscle by the overaction of the yoke muscle of the opposite side when the eye is turned in the direction of action of the weak muscle. This is an important sign and should always be looked for. When present, it is a sure sign that there has been a paralysis of a muscle.

*Accommodative Squint*—In a total of 68 cases, or in 40 per cent of the whole series, some accommodative element was present, in less than one half of these was the squint completely accommodative. Those cases in which there is an accommodative element only belong to another group, with a different causal factor to which a sufficient hyperopia is added to give an excessive convergence tone.

The diagnosis of an accommodative squint is made on the finding of an abnormal amount of hyperopia for the age, on an increase of the squint for near vision and on the partial or complete disappearance of the squint when corrective glasses have been worn for a sufficient period of time (six months or more).

*Undetermined Etiologic Factor*—There remain 73 cases, or 42 per cent of the total series, in which no etiologic factor could be found. As already mentioned, 35 of the 68 cases included in the group of accommodative squint were subsequently found to have characteristics which should include them in the group of undetermined cause. Hence, if these cases are included, it raises the total to 108, or 63 per cent of the total series.

We do not believe that anisometropia of itself causes squint. The vast majority of anisometropic patients are found to have straight eyes. Furthermore, the 15 cases (9 per cent of the total series) in which a difference of at least 1.50 D. in sphere or cylinder was found in the refractive error of the two eyes could be placed in the paralytic or the accommodative group or in the group of undetermined origin, in an even distribution, according to the criteria used for these respective groups. In 4 cases the squint was of the paralytic type, in 3, of the purely accommodative type, in 3 there was an accommodative element, and in 5 the cause was undetermined. Anisometropia has no characteristics which justify regarding it as a separate etiologic entity.

#### CORRESPONDENCE IN RELATION TO CAUSAL FACTOR

Paralysis of a muscle shows no tendency toward one type of correspondence. In cases of purely accommodative squint there is normal correspondence as a rule, i. e., in 90 per cent of cases. In most cases of squint with an accommodative element, i. e., in 80 per cent, there is anomalous correspondence. In this, as in other respects, they are like the cases of squint of undetermined cause.

In 82 per cent of the cases of squint of undetermined cause there was anomalous correspondence. Can one explain the anomalous correspondence in this group and in the cases with an accommodative element? In order to throw light on this question, the cases were

TABLE 3—*Relation of Angle of Squint to Type of Correspondence*

Angle of Squint, Degrees	Correspondence				Total Cases	
	Normal		Anomalous		Number	Per Cent
	Number	Per Cent	Number	Per Cent		
0-10	20	83	4	17	24	14
10-15	12	63	7	37	19	12
15-20	6	25	18	75	24	14
20-30	8	24	26	76	34	21
30-40	8	24	25	76	33	20
40-50	4	14	25	86	29	18

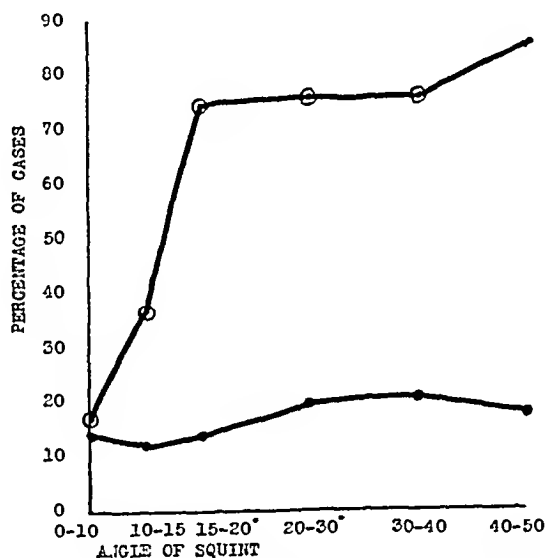


Chart 1—Relation of angle of squint to type of correspondence. The line with hollow circles indicates the percentage of abnormal correspondence, the line with solid circles, the distribution of the total series of cases.

analyzed according to the relations of the following factors: (a) relation of correspondence to angle of squint, (b) relation of angle of squint to causal factor, (c) relation of correspondence to alternation, (d) relation of correspondence to age of incidence, (e) relation of correspondence to duration of squint and (f) relation of correspondence to amblyopia.

*Relation of Angle of Squint to Correspondence*—Since the excessive convergence innervation appears to be the primary cause of squint, it would seem logical to regard the angle of squint as an index of the degree of this innervation. Does the degree of innervation as indicated by the angle of squint show any constant relation to the type of correspondence? (Table 3 and chart 1)

Our studies show that most patients with squint of low angle had normal correspondence, the percentage of incidence of anomalous correspondence rose as the angle of squint increased. Of patients with squint of 40 to 50 degrees, 86 per cent had anomalous correspondence. The graph shows a sharp rise in the percentage incidence of anomalous correspondence with the angle of squint between 15 and 20 degrees, as against the fairly even distribution of the total number of cases throughout a range in angle of squint up to 50 degrees. The significance of this should be investigated further.

TABLE 4—*Relation of Angle of Squint to Causal Factor*

Angle of Squint, Degrees	Paralytic		Accommodative		Accommodative Element		Undetermined	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
0 10	4	15	15	50	0	0	5	7
10 15	3	12	7	23	4	12	4	6
15 20	1	4	2	7	4	12	15	22
20 30	6	23	4	13	13	40	11	16
30 40	7	27	2	7	7	21	17	25
40 50	5	19	0	0	5	15	16	24

TABLE 5—*Relation of Angle of Squint to Causal Factor*

Angle, Degree	Paralytic		Accommodative		Accommodative Element		Undetermined	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
0 10	1	17	15	62	0	0	5	21
10 15	3	17	7	39	4	22	4	22
15 20	1	5	2	9	4	15	15	62
20 30	6	22	4	15	1	45	4	16
30 40	7	21	2	6	7	21	17	52
40 50	5	19	0	0	5	19	16	62

*Relation of Angle of Squint to Causal Factor* (table 4).—The angle of squint has no relation to paralysis. On the other hand, the vast majority of purely accommodative squints were of low angle—73 per cent were of 15 degrees or under. Squints of undetermined cause showed just the opposite—only 13 per cent were of 15 degrees or under.

If one is dealing with a squint of low angle, the chances are that it is accommodative, whereas if the squint is of high angle, i. e., 40 to 50 degrees, the chances are in favor of its belonging to the group of undetermined cause (table 5).

*Relation of Correspondence to Alternation*.—There is a marked difference between a monocular squint in which the person cannot fix

with the squinting eye, and an alternating squint, in which he constantly shifts from one eye to the other, but between these two extremes there is no sharp line of demarcation. Strictly speaking, in alternating squint the patient uses either eye in the primary position without any preference. In borderline squint the patient can alternate the fixing eye but shows a preference for one eye. Monocular squinters are those who habitually use only the one eye.

Eighty-three per cent of persons with alternating squint have anomalous correspondence. However, it is apparent that alternation itself is not the cause of anomalous correspondence, since monocular squinters do not have predominantly normal correspondence but are about equally

TABLE 6—*Relation of Correspondence to Alternating Squint*

Type	Correspondence				Total Cases	
	Normal		Anomalous		Number	Per Cent
	Number	Per Cent	Number	Per Cent		
Alternating	10	17	49	83	59	34
Borderline	7	37	12	63	19	11
Monocular	47	48	50	52	97	55

TABLE 7—*Relation of Alternating Squint to Causal Factor*

Type of Squint	Paralytic		Accommodative		Accommodative Element		Undetermined	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Alternating	9	16	4	7	11	18	34	59
Borderline	3	16	0	0	7	37	9	47
Monocular	18	20	28	30	17	18	30	32

divided between persons with normal and persons with anomalous correspondence (table 6)

What factors are present in alternating squint which probably predispose the patient to anomalous correspondence? Table 7 shows that most cases of alternating squint, i. e., 59 per cent, belong in the group of undetermined cause.

Patients with alternating squint have the largest angle of squint, which, as has been seen (table 3 and graph 1), predisposes to anomalous correspondence. The close tie-up between angle of squint and anomalous correspondence also explains the even distribution of types of correspondence in monocular squinters. Table 7 shows that there is no one outstanding category so far as cause of squint is concerned in the monocular class. Further, the angles of squint in cases of monocular squint are about equally distributed over the whole range of angles

As one would expect, the borderline cases fall between alternating and monocular squint in predominance of anomalous correspondence

*Relation of Correspondence to Age of Incidence*—It is frequently difficult to determine with accuracy at what age a squint began, but in private cases the history is usually of more value. On this basis, the age of incidence in this series of cases is as follows (table 8)

In nearly all the cases the squint appeared in the first four years of life. When the cases are grouped according to the etiologic factor

TABLE 8—*Relation of Correspondence to Age of Incidence\**

Birth	Age Incidence, Year	Number of Cases 53	Per Cent 33
1		27	17
2		24	15
3		23	17
4		21	13
5		4	2.5
6		2	1
7		3	1.5
Totals		163	100

\* Cases of squint beginning at birth include those occurring up to the first year of life, and similarly with each year entry

TABLE 9—*Relation of Age Incidence to Cause of Squint*

Age Incidence	Paralytic		Accommodative		Accommodative Element		Undetermined	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Birth	12	29	4	9	2	5	24	47
Up to 1 yr	1	10	4	40	0	0	5	50
Up to 2 yr	4	14	3	10	7	24	15	32
Up to 3 yr	4	17	2	9	8	35	9	39
Up to 4 yr	4	15	4	15	10	37	9	33
Up to 5 yr	2	9	9	41	7	32	4	18
Up to 6 yr	2	22	4	44	3	34	0	0

(table 9), it appears that the majority of cases of squint beginning in the first two years belong to the group of undetermined origin. At about the second year the group with an accommodative element shows an increase, and at about the fourth year the group of purely accommodative squint takes the lead. This is interesting in that it shows a further relationship of the group with an accommodative element to both the group of squint of undetermined cause and the group of accommodative squint.

If one examines the figures which relate correspondence to age of incidence, one notes a tendency of anomalous correspondence to be

predominant in cases of squint which began in the first four years of life. In the cases in which it appeared in the fourth or fifth year normal correspondence predominates slightly. This appears to be due to the onset of the accommodative type of squint at this period. The age of incidence itself does not seem to be in any way a determining factor of the type of correspondence. Analysis of one group of cases, i. e., those of squint of undetermined cause, shows no conspicuous difference in the type of correspondence found throughout the range of incidence from birth to 5 years of age (after which no cases occurred) (chart 2)

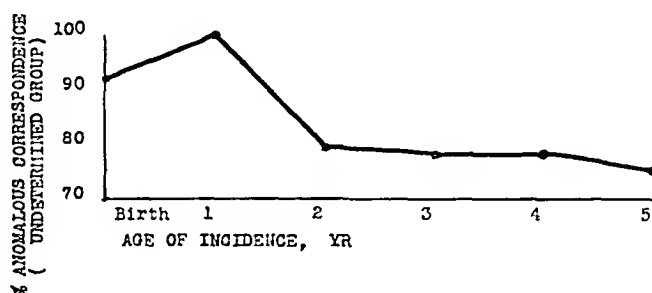


Chart 2—Relation of age of incidence to anomalous correspondence of squint of undetermined cause

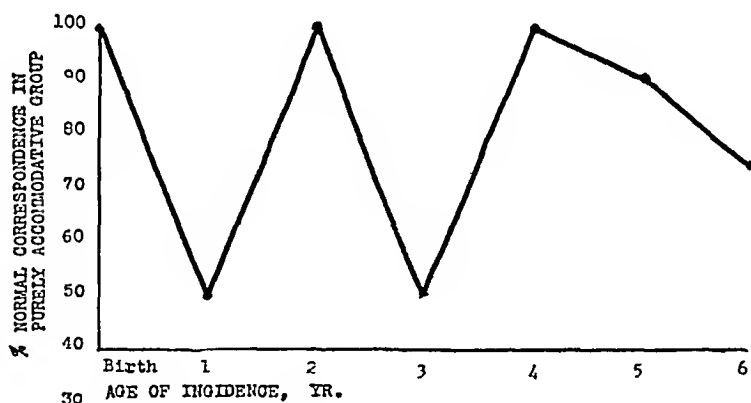


Chart 3—Relation of age of incidence to normal correspondence in cases of purely accommodative squint

This is also true of normal correspondence in the cases of purely accommodative squint (chart 3)

*Relation of Correspondence to Duration of Squint*—It is generally held that the longer a squint has lasted the more certain it is to be associated with anomalous correspondence. This conclusion apparently is not justified. At first glance, a graph showing the duration of squint which represents all types of cases suggests a sharp increase in anomalous correspondence if the squint has lasted from six months to a year (chart 4)

However, it must not be forgotten that one cannot tell the type of correspondence in a child under 3 years of age. The subjects who can be examined within six months of onset will therefore have only that type of squint which begins at about this age (i. e., 3 years), and it has already been seen that this is the accommodative type. On analysis of cases of this one type, it will be seen that there are as many cases with normal correspondence after five years' duration as after six months' duration. Further, analysis of cases of the paralytic type, which serve as an even better control group, shows that there are an equal number of cases of normal and of anomalous correspondence for any given duration of squint. In the paralytic group, for example, even in the cases of squint of five years' duration and over, there were 8 of

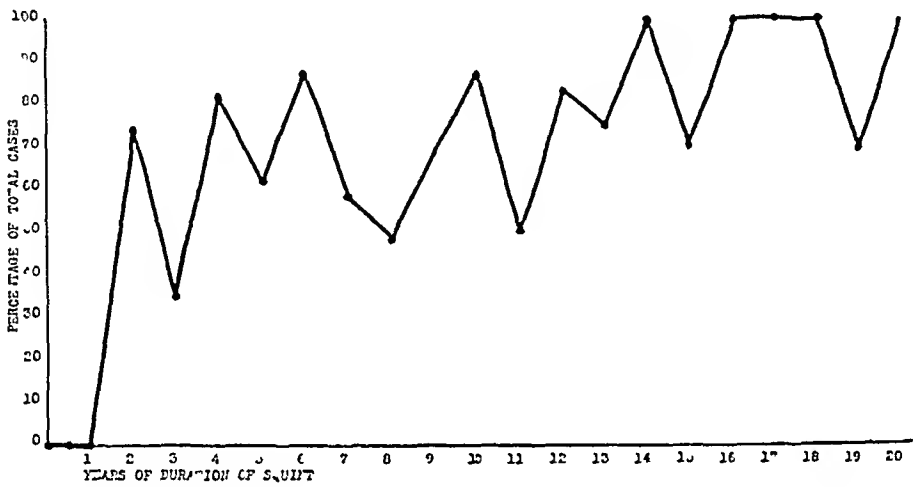


Chart 4—Relation of anomalous correspondence to duration of squint

normal and 9 of anomalous correspondence. Surely, if duration of squint were of any influence in changing the type of correspondence, one would find a greater predominance of anomalous correspondence in these cases.

*Relation of Correspondence to Amblyopia*—Of the cases in which there was no amblyopia (half the total number of all types) anomalous correspondence was found in 69 per cent. This has been taken by some investigators, notably Travers,<sup>2</sup> to indicate that anomalous correspondence and amblyopia are mutually exclusive. It has been inferred that every squinter has a choice of anomalous correspondence or amblyopia as a means of getting out of his dilemma. If this were so, one would expect to find that persons with amblyopia have predominantly normal correspondence. This is not so, however, as only 43 per cent of the subjects with amblyopia (with a difference in acuity of the two

eyes of at least four lines on the standard Snellen charts) had normal correspondence

Amblyopia seems to depend on factors other than correspondence chiefly on whether the squint is monocular or alternating

#### COMMENT

A statistical analysis of a series of cases of convergent squint shows certain correlations between the type of retinal correspondence and the motor disturbances. The most striking feature is the relationship between the type of correspondence and the angle of squint. Persons with squints of low angle have predominantly normal correspondence, whereas persons with squints of 15 to 20 degrees and over usually have anomalous correspondence. There is a sharp rise in the percentage of anomalous correspondence at approximately 15 degrees of convergence. The significance of this remains to be determined.

The angle of squint may be regarded as an index of the degree of excessive convergence innervation causing the squint. The squints of low angle fall largely into the accommodative group, and the excessive convergence innervation is caused by an abnormal amount of hyperopia, as first elucidated by Donders. The squints of large angle belong predominantly in the class for which no causal factor is known and are therefore said to be of undetermined cause.

Analysis of our cases indicates that age of incidence, duration of squint and presence or absence of amblyopia have little to do with determining the type of correspondence. All these factors have been considered by previous authors to be determining factors in the type of correspondence found in any case.

There is a third type of squint with an accommodative element, as well as an another, as yet undetermined, etiologic factor and this type falls halfway between the purely accommodative squint and the squint of undetermined cause in all aspects studied.

The close tie-up between squint of undetermined cause and the presence of anomalous correspondence raises the question as to which is the cause and which is the effect. It is customary to regard anomalous correspondence as an adaptation to the motor disturbance, if this is true, one can say that it seems to be conditioned by an angle of squint in excess of 15 degrees. (Many interesting speculations could be made regarding this but would not be profitable in the present state of knowledge.)

On the other hand, it is possible that the cause of the squint of undetermined origin is anomalous correspondence itself, that the latter is the cause of the excessive convergence innervation and that it is present at birth as an anomaly, instead of normal correspondence. It



results in work on mice and guinea pigs, and Chain, Fiorey and co-workers<sup>6</sup> in their experiments on mice, rats and cats found penicillin to be most effective in controlling subcutaneous infections with *Cl welchii*.

The incidence of anaerobic infections of the eye is probably greater than is generally accepted, especially in perforating war injuries. To my knowledge, no report is available on the etiology of intraocular infections in the recent war. It is safe to say that if routine cultures on thioglycollate broth were made of the vitreous of eyes enucleated because of post-traumatic panophthalmitis more anaerobic infections would be detected. In the literature a moderate number of cases are recorded in which anaerobes were identified as the cause of post-traumatic endophthalmitis. The first case was reported by Chaillous<sup>7</sup> in 1904. He added a second case in 1905.<sup>8</sup> Since these observations, 25 cases have been described in the literature. Morax<sup>9</sup> reported a case following explosion of a grenade in World War I. Ridley<sup>10</sup> cited a case of endophthalmitis due to infection with *Cl welchii* following injury by an intraocular foreign body. Recovery followed evisceration. Rieger<sup>11</sup> observed 5 cases of septic endophthalmitis following perforating injury and described as characteristic a fulminant course with general malaise and fever. In these cases no gas bubbles were seen in the anterior chamber.

By culture of material obtained by vitreous punctures, various anaerobes were demonstrated in these cases. The fulminant development of the inflammation often made evisceration necessary. These cases occurred before penicillin became available.

Chaillous<sup>8</sup> and Schumacher<sup>12</sup> produced infection in the eyes of rabbits by injecting *Cl welchii* into the anterior chamber and vitreous. In extensive work on experimental infection with anaerobes, Morax and Chiazarro<sup>13</sup> were unable to produce progressive endophthalmitis.

6 Chain, E, and others. Penicillin as a Chemotherapeutic Agent, *Lancet* **2** 226 (Aug 24) 1940.

7 Chaillous, J. Infection traumatique du globe oculaire par un microbe anaerobique, *Rec d'opht* **26** 678, 1904.

8 Chaillous, J. Deux cas d'infection traumatique du globe oculaire par un microbe anaerobie (*bacillus perfringens*), *Ann d'ocul* **134** 115, 1905.

9 Morax, V. Des infections du globe oculaire par microorganismes anaerobies, *Bull Acad roy de med de Belgique* **7** 321, 1927.

10 Ridley, F. Gas Gangrene Panophthalmitis, *Tr Ophth Soc U Kingdom* **49** 221, 1929.

11 Rieger, H. Ueber Wundinfektion des Augapfels mit Erregern der Gasbrandgruppe, *Arch f Ophth* **137** 71, 1937.

12 Schumacher, G. Anaerobe Bazillen bei Augenverletzungen, *Klin Monatsbl f Augenh* **46** 34, 1908.

13 Morax, V, and Chiazarro. Sur l'infection due cristallin. Recherches cliniques et experimentales, *Ann d'ocul* **164** 241, 1927.

by injection into the anterior chamber. They succeeded, however, when they inoculated the lens directly. These observations were confirmed by an investigation in the Knapp Memorial Laboratory<sup>14a</sup> in which the chemotherapeutic effect of penicillin iontophoresis on the test lesion was studied. This treatment failed to check the infection, and it was concluded that "it appeared unlikely that treatment of anaerobic infections of the human eye can overcome the twin disadvantages of the low susceptibility of the organisms to penicillin and the poor permeability of the lens."

In view of the failure of penicillin iontophoresis to check infection of the lens with *Cl. welchii*, the present study was undertaken with direct injection of penicillin into the lens. The investigation was extended to a similar treatment of infection of the vitreous produced by inoculation of the vitreous with the same strain of *Cl. welchii*. This therapy had been effective in control of experimental staphylococcic infections of the lens and of infections of the vitreous with pathogenic staphylococci and with pneumococci type III<sup>15</sup>. In a preliminary experiment, the sensitivity to penicillin of the strain of *Cl. welchii* was tested and found to be average, since 0.1 Oxford unit per cubic centimeter inhibited growth of the culture.

#### EXPERIMENTAL INFECTIONS OF THE LENS

*Preliminary Experiment*—The concentration of penicillin in the lens was determined after the direct injection of 0.05 cc. of a solution of penicillin sodium containing 5,000 units per cubic centimeter. Six eyes were thus treated. In 1 rabbit the lenses were removed after forty-eight hours, the concentrations were 0.14 and 0.12 Oxford unit per gram, respectively, in the lenses of the right and the left eye. In the lenses of the other 2 rabbits only traces of penicillin were found after intervals of twenty-four and ninety-six hours.

*Technic of the Experiments*—The technic of inoculation was similar to that used by von Sallmann<sup>14</sup>. The pupil was dilated with 2 per cent homatropine hydrobromide, local anesthesia was obtained by installation of 0.1 per cent nupercaine hydrochloride. General anesthesia was induced with ether. A 27 gage needle was inserted obliquely through the limbus at 12 o'clock. Infection was produced by injecting 0.05 cc. of a  $10^{-4}$  dilution of the culture of *Cl. welchii*, as this had been found to be an adequate test dose. Both eyes of 12 rabbits were

14 von Sallmann, L. (a) Penicillin and Sulfadiazine in the Treatment of Experimental Intraocular Infections with *Staphylococcus Aureus* and *Clostridium Welchii*, *Arch. Ophth.* **31** 54 (Jan.) 1944, (b) Experimental Study of Penicillin Treatment of Ectogenous Infection of Vitreous, *ibid.* **32** 179 (Sept.) 1944, (c) Penicillin Therapy of Infections of the Vitreous, *ibid.* **33** 455 (June) 1945.

15 Leopold, I. H. Intravitreal Penetration of Penicillin and Penicillin Therapy of Infection of the Vitreous, *Arch. Ophth.* **33** 211 (March) 1945.  
von Sallmann<sup>14</sup>

thus inoculated. In the first series, 8 eyes were treated after a three hour interval with 0.1 cc. of a solution of sodium penicillin containing 5,000 Oxford units per cubic centimeter. The injection was made in the same manner as that of the culture of *Cl. welchii*. In the second series, 8 eyes were treated similarly after a six hour interval. The remaining 8 eyes were used as controls. Ten of the 12 rabbits were observed at frequent intervals over a period of six weeks. The eyes were then removed and fixed in Zenker's solution. Sections were stained with hematoxylin and erythrosin and with the Van Gieson solution. One rabbit sustained a broken back at the time of injection. The animal was observed for four days and then killed. Another rabbit was found dead after twenty-five days. The eyes of these 2 rabbits were removed, and the histologic descriptions are included in the report on results.

### RESULTS

The clinical changes observed in the first few hours after inoculation were probably caused for the most part by the trauma of injection. These changes consisted of dense fibrinous exudate in front of the pupil, dilatation of the vessels of the iris and strong aqueous flare with cells in the anterior chamber. The activity of the infection became evident in the next twenty-four hours. There were intense ciliary injection and purulent exudate in the anterior chamber. The wound in the lens became covered with yellow exudate, which extended into the superficial and deep layers of the anterior cortex. The iris was extremely swollen, and the pupil became occluded by an inflammatory membrane. The corneas of 3 eyes showed a high degree of vascularization. The purulent endophthalmitis spread rapidly into the posterior chamber and the vitreous. The globes gradually became shrunken, and histologic examination showed the picture of purulent panophthalmitis with severe destruction of the retina and choroid.

Clinical observations on the first series of eyes, which were treated after three hours, showed that the inflammation in the anterior segment was striking for the first two weeks but was not as intense as that in the untreated eyes. Posterior synechias formed, but in only 2 of the eyes did the pupils become occluded by an inflammatory membrane, as it did in all the control eyes. At the end of two weeks the infection in the anterior chamber gradually subsided. The inflammatory process did not progress in the lenses of the treated eyes, and after six weeks only 2 showed more than circumscribed linear cortical cataracts. These opacities interfered more or less with the clinical observation of the vitreous and the fundus. Only 2 treated eyes showed histologically an active infection of the lens, 1 of these was the only treated eye to show an abscess of the vitreous, with leukocytic infiltration of the retina. Three eyes showed localized atrophy of the retina, and 1 of these presented also a detachment of the retina (tables 1 and 2).

In the second series, treated after a six hour interval, 3 of the 8 eyes showed the clinical signs of a severe infection in the anterior chamber, with iris bombé, cells in the anterior chamber and seclusion

of the pupil. All the lenses which could be seen had linear cortical cataracts. Histologically, only 2 of the 8 treated eyes showed an uncontrolled infection in the lens and vitreous. One of these 2 eyes presented also a leukocytic infiltration of the cornea with exudate in the anterior chamber and necrosis of the iris. An accumulation of

TABLE 1—*Effect of One Intravitreal Injection of Commercial Sodium Penicillin (5,000 Units per Cubic Centimeter) on Infections of Lens and Vitreous with Clostridium Welchii*

	Site of Inoculation			
	Lens		Vitreous	
	3	6	3	6
Hours between inoculation and treatment				
Number of eyes treated	8	8	8	8
Infection definitely checked	6	5	7	6*
Infection not checked	2	3	1	2
Number of control (untreated) eyes	4	4	8	8
Number of control eyes with panophthalmitis	4	4	6	7

\* Infection checked but with extensive damage to the retina

TABLE 2—*Damage to Treated Eyes*

	Site of Inoculation			
	Lens		Vitreous	
	3	6	3	6
Hours between inoculation and treatment				
Number of eyes treated	8	8	8	8
Lens				
Clear	0	0	6	4
Traumatic cataract	6	8	1	2
Cataract complicated to infection	2	0	1	2
Vitreous				
Normal	7	6	6	1
Moderate number of inflammatory cells	0	0	1	1
Organized strands	0	1	1	6
Abscess	1	1	0	0
Retina				
Normal	5	5	3	0
Local atrophy	3	3	4	2
Detachment	1	2	1	6

leukocytes was evident in the posterior pole of the lens, while the vitreous was filled with exudate and the nerve was drawn forward by the organizing exudate. The other eye revealed an extensive abscess involving the lens, vitreous and retina. Three eyes showed localized atrophy of the retina.

#### EXPERIMENTAL INFECTIONS OF THE VITREOUS

*Preliminary Experiments*—Ten eyes of mature chinchilla rabbits were used to determine whether it was possible to obtain a standard

test lesion with the intravitreal injection of the same strain of *Cl welchii* as that used in the lens experiment. The bacilli were cultured eighteen hours in thioglycollate broth, centrifuged three times, washed in 0.9 per cent solution of sodium chloride and suspended in the following concentrations of the original culture undiluted,  $10^{-1}$ ,  $10^{-2}$ ,  $10^{-3}$  and  $10^{-4}$ . It was determined that 0.05 cc of a  $10^{-1}$  dilution of the culture gave an adequately reproducible lesion which, in general, led to progressive and destructive endophthalmitis.

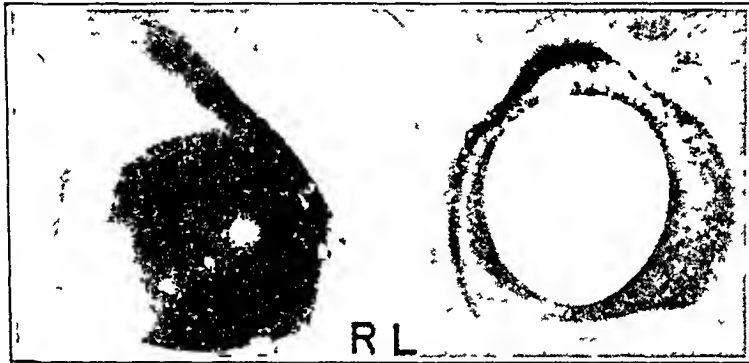
*Technic of Experiments*—Local anesthesia was obtained with instillation and subconjunctival injection of a 0.1 per cent solution of nupercaine hydrochloride. An injection of 0.05 cc of a  $10^{-1}$  dilution of the culture of *Cl welchii* was made into the vitreous while the eye was rotated downward with fixation forceps. The injection was made with the needle directed backward at an angle of 45 degrees to the axis of the globe, at a point 6 to 8 mm behind the limbus. A tuberculin syringe and a short, sharp, 27 gage needle were used.

Two groups of experiments were conducted to ascertain the effectiveness of penicillin in controlling the course of the subsequent endophthalmitis. Into both eyes of 16 rabbits was injected, with the use of local anesthesia, the test dose of 0.05 cc of a  $10^{-1}$  dilution of the culture of *Cl welchii*. In the first series of 8 rabbits, 0.1 cc of a solution of sodium penicillin containing 5,000 Oxford units per cubic centimeter was injected into the vitreous of the right eye three hours after the inoculation, and 0.1 cc of 0.9 per cent solution of sodium chloride was injected into the vitreous of the left eye. In the second series of 8 rabbits, the same dose was injected into the right eye six hours after inoculation, and the control eyes were given an injection of 0.9 per cent solution of sodium chloride. Examination with the slit lamp and ophthalmoscopic studies were made daily during the subsequent week and at frequent intervals thereafter. At the end of six weeks all the eyes were enucleated and fixed in Zenker's solution. Sections were stained with hematoxylin and erythrosin and the Van Gieson solution and studied histologically.

*Results*—In the 16 control eyes the various stages of the infection were observed. The inflammatory signs attributable to the infection developed usually within forty-eight hours. At that time a moderate amount of purulent and fibrinous exudate was seen in the anterior chamber. Opacities in the vitreous developed rapidly, and details of the fundus could no longer be seen. By the third or fourth day a definite abscess was present in the vitreous in 10 of the 16 control eyes. The signs of inflammation in the anterior chamber often regressed after the third or fourth week, and the injection of the eye subsided. The anterior chamber cleared, the iris became atrophic, and the contracted pupil closed by organization of exudate. The infection remained localized in the eye, and no signs of a systemic infection were noted during the period of observation. Thirteen of the 16 control eyes were considered lost as a result of the infection. One eye exhibited an early inflammatory reaction in the vitreous, which cleared gradually, leaving little histologic evidence of its presence. In the other 2 eyes the inflammation did not lead to complete destruction of the retina.

but resulted only in strands of vitreous and retinal detachment. Seven of the control eyes showed changes in the posterior cortex of the lens. In 2 of these eyes the changes became evident within the first few days and were considered to be of traumatic origin. In the other 5 eyes the cortical opacities became evident late in the period of observation and were considered to have been caused by infection.

Of the 8 eyes in the first series, treated three hours after inoculation, 4 showed localized atrophy of the retina at the site of injection, and another eye presented a flat detachment of the retina. Two eyes had cortical changes in the lens, appearing early in 1 eye and late in the period of observation in the other. Of the 8 eyes in the second series, treated six hours after inoculation, none demonstrated serious inflammatory changes in the anterior chamber, 4 revealed changes in the cortex of the lens, and 6 showed extensive changes in the vitreous, consisting of strands, with partial or total detachment of the retina.



Appearance of eyes showing effect of treatment with sodium penicillin on experimental infection of the vitreous with *Clostridium welchii* six weeks after injection of the drug. The right eye was treated with injection of the penicillin six hours after inoculation with the culture, the left eye served as control.

These changes were observed both clinically and histologically. Practically no inflammatory cells were observed histologically, so the active infection in all these eyes was considered to have been controlled, although extensive damage had probably destroyed the function of the eye.

#### COMMENT

The attempt to control anaerobic infections of the lens by the intralenticular injection of penicillin was decided on because this form of therapy had proved effective in staphylococcal infections of the lens<sup>14</sup> and because of the impossibility of introducing the drug into the lens by any other means. Certain weaknesses, however, were inherent in this type of therapy. Only minimal amounts of the solution could be injected into the lens, and the degree of leakage of the introduced substance from the wounds could not be controlled, nor could the distribution be judged. These disadvantages did not prevent the favorable results obtained with

the infection of the lens with *Cl welchii*, which is one of the most reliable test lesions of the eye. To my knowledge, this is the first report of a beneficial effect of chemotherapy on an intralenticular infection with an anaerobe.

In the first series of eyes, treated three hours after inoculation, the infection was controlled in 6 or 8 eyes, and the damage to the globes was negligible except for the traumatic cataracts. In 1 eye the infection was probably checked, but the lens had still a clump of leukocytes and the retina exhibited partial atrophy. In the remaining eye, recorded as a therapeutic failure, an abscess formed in the vitreous. When the interval before treatment was prolonged to six hours, the infection was checked in 5 of 8 eyes, but the damage to the eyes by the formation of strands of vitreous with retinal detachment made it obvious that a longer interval could not be considered.

The results obtained with topical treatment with penicillin of infections of the lens may well be compared with those reported in the systemic treatment of infection with *Cl welchii* in mice by McIntosh and Selbie<sup>4</sup> and Hac.<sup>5</sup> When the treatment was delayed longer than three hours after the inoculation, the percentage rate of survival decreased steeply. It has repeatedly been emphasized that satisfactory results with penicillin therapy in intraocular infections were dependent on the early initiation of the treatment. The observations in the present series not only confirm this experimental evidence with other types of infections but indicate that under the conditions of these experiments the interval between inoculation and treatment must be reduced to three hours.

In several of the beneficially treated eyes localized areas of retinal degeneration were observed which were similar to those produced by the injection of penicillin alone without the presence of an infection.<sup>14c</sup> Although the possibility cannot be excluded that the toxin of the bacilli produced some of the lesions in the retina, it is not improbable that the close topical relationship between a depot of the concentrated penicillin solution and the retina caused these changes. No attempt was made to use lower concentrations of penicillin to eliminate this danger, as it was essential to inhibit the growth of the organisms as early as possible. This purpose was thought to be achieved better with higher concentrations, since diffusion would be more rapid from a more concentrated solution.

In the vitreous experiments a reliable standard lesion had first to be determined. The one finally used, obtained by the injection of 0.1 cc of a  $10^{-1}$  dilution of a culture of *Cl welchii*, was not entirely satisfactory, since in only 13 of the 16 control eyes did panophthalmitis develop. In 2 of the 3 remaining control eyes, the endophthalmitis was self limited but led to the formation of strands in the vitreous with retinal detachment. In the last control eye the inflammation subsided without causing great

damage Nevertheless, the number and the condition of the beneficially treated eyes could be considered significant The less favorable results in the series with the six hour interval could be interpreted similarly to the results in the respective series in the lens experiments

#### CONCLUSIONS

1 Direct injection of penicillin into the lens and vitreous gave satisfactory results in controlling infections with *Cl welchii* when the therapy was instituted within three hours after the inoculation

2 Less favorable results were obtained when the interval between the infection and the treatment was increased to six hours

3 The beneficial effect in the three hour series was obtained with moderate damage to the structures of the eye

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# LIPEMIA RETINALIS

## Report of a Case

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AND

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**L**IPEMIA retinalis, although undoubtedly observed more frequently than published reports might indicate, only infrequently has been the subject of formal dissertations, and, because the intraocular picture is vividly striking, interest in this subject has been stimulated largely by the contributions of ophthalmologists. The antecedent and accompanying acidosis, whether sufficient to cause only drowsiness or so progressively severe as to cause the afflicted person to become comatose, is of course dramatic to the point of demanding remedial attention, to the exclusion, at least for the time being, of attention being directed to organs or systems that might be of interest to the examiner but do not involve the immediate question of life or death. It is not unusual, therefore, as occurred in this case—the sixty-sixth instance to be reported—that the eyegrounds are not immediately examined on admission. It is of interest, however, to mention that the patient under discussion already had undergone a previous, known episode of lipemia retinalis of diabetic origin. Wagener,<sup>1</sup> Lepard<sup>2</sup> and Kauffman<sup>3</sup> each have reported an instance of lipemia retinalis not attributable to diabetes mellitus, and it is possible that in the case recently reported by Igersheimer<sup>4</sup> the disease may not be essentially diabetic in origin.

## REPORT OF CASE

D C, a poorly developed, fairly well nourished white girl of  $2\frac{1}{3}$  years, was admitted in diabetic coma to the Babies Hospital in May 1931, her first admission.

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Presented before the New York Academy of Medicine, Section of Ophthalmology, April 15, 1946. A discussion of this paper was published in the October 1946 issue of the ARCHIVES, page 521.

1 Wagener, H P. Lipemia Retinalis. Reports of Three Cases, *Am J Ophth* **5** 521-525 (July) 1922.

2 Lepard, C W. Lipemia Retinalis in Nondiabetic Patient, *Arch Ophth* **32** 37-38 (July) 1944.

3 Kauffman, M L. Lipemia Retinalis, *Am J Ophth* **26** 1205-1208 (Nov) 1943.

4 Igersheimer, J. Ocular Disturbance in Case of Acromegaly Complicated by Diabetes, *Arch Ophth* **27** 330-341 (Feb) 1942.

She had been a normal full term baby, but delivery was difficult and forceps had been employed. Her parents stated that she had been healthy and active until twelve weeks prior to her admission to the hospital. The family history was essentially without significance, but one paternal grand-aunt had had diabetes mellitus in her middle years.

A neighborhood physician examined the child when she manifested listlessness and sleepiness, accompanied with anorexia, several weeks prior to her admission. Her appetite improved, without obvious reason, but the increased water intake, acetone breath and urinary frequency were attributed to the appearance of her first teeth. Consultation was requested on the day prior to her admission, when breathing became labored and the previously instituted diet failed to keep the urine free from sugar.

She was comatose on admission, and there were impairment of resonance and suppressed breathing over the lower left side of the chest. The systolic and diastolic blood pressures were 85 and 45 mm of mercury, respectively. Urinalysis revealed a 4 plus reaction for sugar and acetone and diacetic acid. Determination of the blood sugar revealed a level of 500 mg per hundred cubic centimeters. The carbon dioxide-combining power and the fat content of the blood were not determined. The eyegrounds revealed a classic picture of moderately severe lipemia retinalis. Response to indicated therapy was excellent, and the patient was discharged from the hospital one month after admission.

She was regularly observed in the Vanderbilt clinic during the next four years, admission again was advised in October 1935 because of an indolent septic infection of the left hand sequential to a moderate bruise sustained a few days before. She was discharged in less than two weeks, after intensive treatment directed toward the regulation of the diabetes mellitus. There was no suggestion of lipemia retinalis on this, her second, admission to the hospital. She returned at intervals for observation and examination in the Vanderbilt clinic until November 1940, when admission to the hospital again was advised to determine the cause of recurrent epistaxis and questionable enlargement of the liver. She was 11¾ years of age at this time.

Examination on this admission revealed a poorly developed but fairly well nourished girl, with a temperature of 101 F, a radial pulse of 130 beats per minute, essentially normal respiration and systolic and diastolic blood pressures of 130 and 100 mm of mercury, respectively. The liver was moderately enlarged and the abdomen moderately distended, but the spleen was not palpable. There were some lesions of xanthoma diabetorum over the elbows and knees. Urinalysis revealed a strongly positive reaction for sugar, acetone bodies and diacetic acid with a faint trace of albumin. Examination of the formed elements of the blood revealed moderate decrease in the red cells, leukocytosis and relative lymphocytosis. The sedimentation rate was 113 mm in the first hour. The sugar content of the blood was determined as 612 mg per hundred cubic centimeters, and the blood cholesterol was increased to 1,417.6 mg per hundred cubic centimeters. Sulfobromophthalein sodium and bilirubin excretion tests gave normal results. The carbon dioxide-combining power was not determined.

The eyes were essentially normal externally, but their ophthalmoscopic appearance was unmistakably that of lipemia retinalis, which was in accord with the decidedly creamy color of the blood plasma obtained on the day after the patient's admission. The margins of the disks were visualized with difficulty, but the papillary and peripapillary vasculature was a pink-yellowish white and presented no manifest structural contrast to the background of the underlying choroidal

vasculature. The latter uniformly exhibited the same coloration except at the extreme periphery, where the whitish appearance gave way gradually to a yellow-pinkish tinge.

On the day after admission the onset of symptoms characteristic of impending diabetic coma necessitated the administration of appropriate treatment, consisting in this instance in furnishing constantly available insulin in Ringer's solution intravenously. The mild anemia was treated by transfusions of citrated blood,

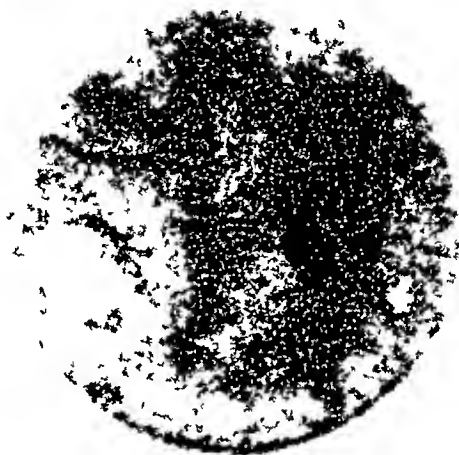


Fig 1—Right eye in a case of lipemia retinalis (third day in hospital)

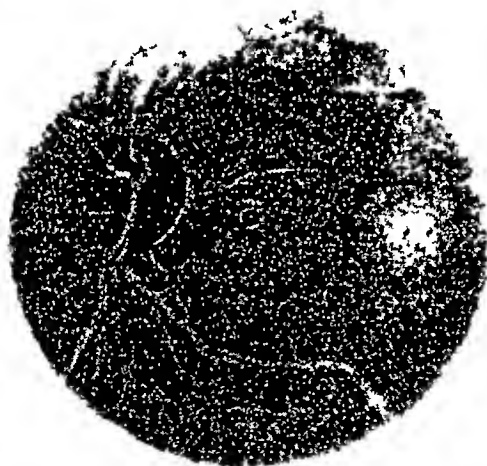


Fig 2—Left eye in a case of lipemia retinalis (twenty-first day in hospital)

with some improvement in the values obtained for all the formed elements except the red cells. The latter did not increase in number, but studies of blood smears revealed no evidence of any blood dyscrasia. Ophthalmologic examination on the third day in the hospital revealed relatively marked improvement in the intra-ocular coloration. The usually easily discernible structures no longer were observed with difficulty, although the general appearance still was strongly sug-

gestive of lipemia retinalis. Retinal photographs were taken on this day because of the generally improved condition of the patient. Subsequent pictures taken three weeks after admission revealed essentially normal eyegrounds, which, however, had been evident on the ninth day after her admission.

The patient was discharged three and one-half weeks after admission, with only minimal enlargement of the liver still determinable, the hemoglobin was evaluated

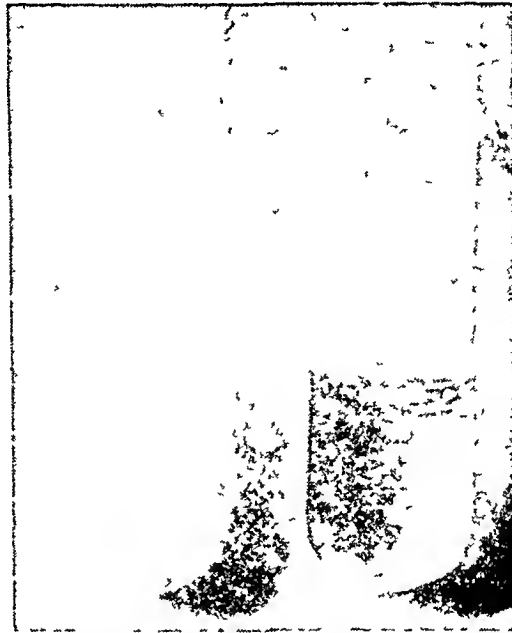


Fig 3—Blood serum, showing color contrast of samples obtained on the second and the twentieth day in the hospital

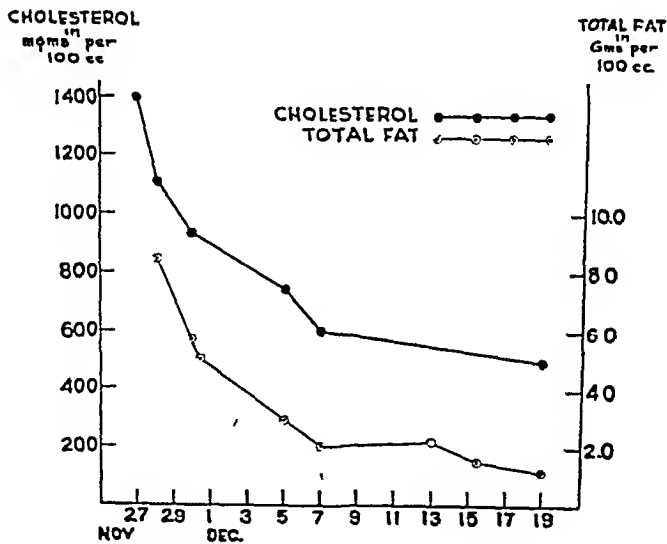


Fig 4—Graph of values for blood fat during hospitalization

at 100 per cent and the red blood cells at 3,850,000 per cubic millimeter, and the diabetes was under excellent control. The cholesterol content, as well as the total fat content, of the blood just prior to discharge returned to near-normal levels of 45 and 10 Gm per hundred cubic centimeters, respectively.

## COMMENT

Lipemia retinalis, the literature of which has recently been adequately reviewed elsewhere, is an uncommonly observed phenomenon seen in the course of an acidotic episode of some severity, occurring chiefly in younger diabetic persons. In this condition abnormal increases of emulsified neutral fats in the blood stream are manifested ophthalmoscopically by characteristic deviations from the normal in the paler color of the eyeground and its contrasting structures. More than 60 cases have been reported to date, however, in at least 3 of these the condition has unquestionably occurred in patients without diabetes. Prior to the use of insulin, in 1922 24 cases were reported, in 17 of which the patient died in diabetic coma.

In the case herewith reported (which appears to be the sixty-sixth on record) the patient experienced two known episodes of lipemia retinalis. The first occurred when she was 2 years of age, on her first admission to the Babies Hospital, in May 1931, while in diabetic coma, the next admission, during which she approached but did not go into coma, was in November 1940 when she was nearly 12 years of age. Values for cholesterol and total fat concentrations determined during the second admission are charted. Photographs of the eyegrounds and of specimens of the blood serum illustrate the color contrasts at the peak of the episode and prior to the patient's discharge from the hospital.

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## INFLUENCE OF THE SUTURE ON COMPLICATIONS FOLLOWING CATARACT OPERATION

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THE first extraction of cataract by Daviel—its two-hundredth anniversary was last year—was followed by several important improvements in surgical technic von Graefe's combined extraction, the intracapsular method, akinesia, fixation of the superior rectus muscle and suturing of the wound All these procedures originated several decades ago By their gradual perfection, the incidence of complete failures has been reduced to less than 1 per cent, as compared with 25 per cent two hundred years ago, 6 to 34 per cent in the statistics of eighty to one hundred and twenty years ago and 3 to 4 per cent in the last year of von Graefe's life The latest measure, although not a technical one, in the direction of eliminating postoperative infection is the prophylactic use of sulfonamide drugs (Guyton and Woods<sup>1</sup>) and of penicillin (Dunnington and Locatcher-Khorazo<sup>2</sup>) As things now stand, all these improvements together relegated the dreaded postoperative inflammation to a place second in importance to the other types of postoperative complications, such as retinal detachment, glaucoma, corneal degeneration and expulsive hemorrhage

Today, a modification of the cataract operation can hardly improve the results impressively, because there are so few failures It is like cutting off one fifth of a second from the record of the 1 mile run. This is harder now than was an improvement of one second thirty years ago Only comparison on the basis of a really large material would show the advantages or disadvantages of a modification of the operation for cataract

The use of the suture in the operation for cataract is steadily gaining followers A decade ago it was used in but few hospitals In 1944 an article in the *Bulletin of Practical Ophthalmology*<sup>3</sup> of Green's Eye

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1 Guyton, J S, and Woods, A C Oral Use of Prophylactic Sulfadiazine for Cataract Extraction, *Am J Ophth* 26 1278, 1943

2 Dunnington, J H, and Locatcher-Khorazo, D Value of Cultures Before Operation for Cataract, *Arch Ophth* 34 215 (Sept) 1945

3 Use of Sutures in Cataract Extraction Report of Survey, *Bull of Pract. Ophth*, May 1944, vol 14, no 1

Hospital, based on a questionnaire answered by 398 ophthalmic surgeons (not answered by 303) disclosed that 79.65 per cent used sutures in the cataract operation. There can be little doubt that this figure is steadily growing. However, 13.57 per cent used conjunctival sutures only, so this number can be deducted from the first from the point of effective protection to the wound. The main reason for the acceptance of the suture by the majority of ophthalmic surgeons in a few short years is the perfection of the needle and thread, which makes introduction of the stitch easy, avoiding damage to the tissue, thus, no infection occurs along the thread. Several excellent papers have dealt with the many advantages gained by the suture. It is not the purpose of this paper to elaborate on this subject. If only the great decrease in the number of wound ruptures and the greater postoperative freedom of movement granted the patient are considered, it is more than worth while to prolong the operation by inserting sutures. Any one who has done a large series of extractions without sutures and remembers the wound ruptures—which amounted to 6 to 20 per cent in various statistical reports—awakening the patient with pain, usually in the early morning hours, as well as the psychologic effect on the patient, will make use of the suture.

However, in the selection of the suture there is a choice of several types. It would be a simple matter to pick the best suture by a comparison of the results if the same surgeon used the various kinds on about an equally large number of patients. The next best method is to compare the results of the various surgeons with one method, in which case the personal factor, the difference in technic and the making up of statistics will somewhat blur the picture. This method will be followed later in this paper, consideration being given to the series in which one or more deep corneoscleral sutures were used, the technic was not changed during the series and the complications and results were fully or partly published (table 1). These limitations explain the omission of large series from this paper, e. g., those of Knapp,<sup>4</sup> Greenwood and Grossman,<sup>5</sup> Berens and Bogart,<sup>6</sup> Klein<sup>7</sup> and F. A. Davis.<sup>8</sup>

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4 Knapp, A. Complications of the Forceps Intracapsular Operation for Cataract, *Arch Ophth* **16** 770 (Nov) 1936

5 Greenwood, A., and Grossman, H. P. An Analysis of 1,343 Intracapsular Cataract Extractions by Forty-Eight Operators Following the Verhoeff Method, *Tr Am Ophth Soc* **33** 353, 1935

6 Berens, C., and Bogart, D. Certain Postoperative Complications of Cataract Operations, *Tr Sect Ophth, A. M. A.*, 1938, p. 238

7 Klein, M. Operation for Cataract, *Brit J Ophth* **26** 93, 1942

8 Davis, F. A. Intracapsular Cataract Extraction, *Arch Ophth* **31** 367 (May) 1944

The papers of Leech and Sugar<sup>9</sup> and of McLean<sup>10</sup> present the results for their series with the conjunctival suture as well as for the series with the deep suture. It is instructive to compare the results of the two series obtained by the same surgeons.

The suture used to close the cataract wound may be superficial, i. e., conjunctival, or deep, i. e., corneoscleral. Between these two types is the episcleral suture. Several series have proved that conjunctival sutures do not reduce, or only insignificantly reduce, the incidence of wound rupture.

#### THE DEEP SUTURE

The deep suture is basically of two types.

1 The Kalt<sup>11</sup> suture. A vertical bite is taken in the cornea, and a vertical or, as later advised, a horizontal bite, in the sclera. Between the two bites the thread runs on the surface. Modifications of this type are Verhoeff's suture,<sup>12</sup> method A, and Burch's suture,<sup>13</sup> both of which include the conjunctiva as well, and the sutures of Liégard,<sup>14</sup> Stevenson,<sup>15</sup> Higgins,<sup>16</sup> Stallard<sup>17</sup> and Mullen,<sup>18</sup> with both bites horizontal.

2 The Mendoza<sup>19</sup> suture. A shallow incision is made in the cornea or limbus, and a suture is placed in the lips of the incision at exactly appositional points. This method has several modifications. The differences are in the site of the preliminary incision, whether in the cornea

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9 Leech, V. M., and Sugar, H. S. Reduction in Postoperative Complications of Cataract Operations, *Arch. Ophth.* **21**:966 (June) 1939.

10 McLean, J. M. A New Corneoscleral Suture, *Arch. Ophth.* **23**:554 (March) 1940.

11 Kalt, E. On the Corneal Suture in Cataract Extraction, *Arch. Ophth.* **23**:421, 1894.

12 Verhoeff, F. H. A Corneo-Sclero-Conjunctival Suture in Operation for Cataract, *Tr. Am. Ophth. Soc.* **25**:48, 1927.

13 Burch, E. P. The Corneo-Scleral Suture in Military Ophthalmology, *Mil. Surgeon* **93**:286, 1943.

14 Liégard, H. Une modification au procédé de suture de la cornée dans l'opération de la cataracte, *Ann. d'ocul.* **149**:119, 1913.

15 Stevenson, cited by Beard, C. H. *Ophthalmic Surgery*, ed. 2, Philadelphia, P. Blakiston's Son & Co., 1914.

16 Higgins, S. G. The Closure of the Cataract Incision, *Am. J. Ophth.* **13**:1099, 1930.

17 Stallard, H. B. A Corneo-Scleral Suture in Cataract Extraction, *Brit. J. Ophth.* **22**:269, 1938.

18 Mullen, C. A Corneo-Scleral Suture for Intraocular Surgery, *Arch. Ophth.* **32**:522 (June) 1944.

19 Mendoza, S. F. Nouveaux faits de suture de la cornée dans l'extraction de la cataracte, *Bull. et mem. Soc. franç. d'opht.* **10**:63, 1892.



TABLE 1—Data on Several Series of Cases of Cataract

Author and Series	No of Cases	Type of Suture	Type of Operation	Delayed and/or Incomplete Closure of Wound	Hemorrhage in Anterior Chamber
Hilding					
Series 1	105	Verhoeff, two sutures	Three peripheral iridectomies		
Series 2	82	Four sutures similar to McLean's	No iridectomy, knife and scissors, intracapsular extraction 70 + 5%†		
Hughes and Owens					
Series 1	425 (no complicated cataract)	McLean's, one or two	Combined intracapsular extraction	1.0%	10.8%
Series 2	380 (no complicated cataract)	McLean's, one or two	Round pupil, intracapsular extraction	0.3%	4.0%
Kirby	100 (consecutive cases in which the intracapsular method was used)	Appositional, three following incision	90 + 1%† intracapsular 52% round pupil		8%
Leech and Sugar					
Series 1	150 (selected)	Conjunctival	Intracapsular extraction 34%	6% No chamber at first dressing	11.3%
Series 2	150	Stallard's	Intracapsular, 51%	2.6%	4.6%
McLean					
Series 1	64 (unselected)	Conjunctival	Intracapsular extraction, 88%	14.1% delayed reformation of chamber or closure of the wound	18.7%
Series 2	110 (unselected)	McLean's (two sutures in 11 cases)	Intracapsular extraction, 88%	3.6%	8.6%
O'Brien	220 (unselected)	Episcleral (six sutures)	Keratome + scissors, 110, Gracie knife, 110 intracapsular extraction, 76%		
Roper	27 (unselected)	Lancaster's (two or three, appositional)	Intracapsular extraction, 80%		3.7%
Stallard	107	Stallard's	Intracapsular extraction, 25%		None
deRoeth					
Series 1	150 (unselected)	Verhoeff, method A	Intracapsular extraction, 63 + 14%†	No chamber at first dressing, 5%, chamber formed in one week, 2%	6.6%
Series 2	150 (unselected)	Author's modification of McLean's, one suture	Intracapsular extraction 67 + 7%†	No chamber at first dressing, 5%, formed in one week, 0	4.7%
Series 3 *	35 (unselected)	Author's modification of McLean's, two sutures	Intracapsular extraction, 22 + 3† cases	No chamber at first dressing 2, chamber formed in one week, 1	2 cases

\* Owing to the small number of cases, the incidence of complications is not given in percentages

† Cases in which the capsule was removed in toto after expulsion of the lens

## Extraction with Use of Deep Corneoscleral Sutures

Prolapse of Iris and/or Vitreous	Amount of Astigmatism Average	Iritis	Retinal Detachment	Glaucoma	Corneal Dystrophy	Vision, Cases with Extraneous Causes of Poor Vision Excluded
2% (incarceration or tiny prolapse) for two series combined	About 1.50 D  For two series combined					20/30 or better, 88%  (results for two series combined)
1.7%	With one suture, 1.7 D	2.8%	1.3%	2.4%		20/30 or better, 85.7%, less than 20/200, 3.3%
1.2%	With two sutures, 1.4 D	1.4%	0.5%	1.6%		20/30 or better, 91.7%, less than 20/200, 1.9%
1% (?)	About 1.5 D	6% + 5% in eyes with previous uveitis	1%	3% + 3% transient		No selection of cases. 20/30 or better, 86% 20/200 or less, 4%
6.6% (iris or vitreous)	1.94 D					
4%	1.82 D					
6.3%	2.56 D					
2.7%	1.32 D					
	Græfe knife, 2.42 D, keratome and scissors, 1.64 D					20/30 or better, 91.8%
7.4%	1.53 D					
	1.5 2.5 D					
3.3% vitreous incarcerated, 7.4%	2.13 D	4.0%	1.3%	2.6%	2%	20/30 or better, 91.5%, less than 20/200, 3.8%
Incarceration of iris, 3% vitre- ous incarcerated, 1.3%	2.12 D, uncomplicated cataract, 1.92 D	4.6%	2%	2%	0	20/30 or better, 90.3%; less than 20/200, 3.8%
Vitreous incarcerated, 1 case	1.66 D	0	0	0	0	20/30 or better in 30 out of 31

TABLE 1—Data on Several Series of Cases of Cataract

Author and Series	No of Cases	Type of Suture	Type of Operation	Delayed and/or Incomplete Closure of Wound	Hemorrhage in Anterior Chamber
Hilding					
Series 1	105	Verhoeff, two sutures	Three peripheral iridectomies		
Series 2	82	Four sutures similar to McLean's	No iridectomy, knife and scissors, intracapsular extraction 70 + 5%†		
Hughes and Owens					
Series 1	425 (no complicated cataract)	McLean's, one or two	Combined intracapsular extraction	1.9%	10.8%
Series 2	380 (no complicated cataract)	McLean's, one or two	Round pupil, intracapsular extraction	0.3%	4.5%
Kirby	100 (consecutive cases in which the intracapsular method was used)	Appositional, three following incision	90 + 1%† intracapsular 52% round pupil		8%
Leech and Sugar					
Series 1	150 (selected)	Conjunctival	Intracapsular extraction 34%	0% No chamber at first dressing	11.3%
Series 2	150	Stallard's	Intracapsular, 51%	2.6%	4.6%
McLean					
Series 1	64 (unselected)	Conjunctival	Intracapsular extraction, 88%	14.1% delayed reformation of chamber or closure of the wound	18.7%
Series 2	110 (unselected)	McLean's (two sutures in 11 cases)	Intracapsular extraction, 88%	3.6%	3.6%
O'Brien	220 (unselected)	Episcleral (six sutures)	Keratome + scissors, 110, Gracie knife, 110 intra- capsular extraction, 76%		
Roper	27 (unselected)	Lancaster's (two or three, appositional)	Intracapsular extraction, 85%		3.7%
Stallard	107	Stallard's	Intracapsular extraction, 25%		None
deRoeth					
Series 1	150 (unselected)	Verhoeff, method A	Intracapsular extraction, 63 + 14%†	No chamber at first dressing, 5%, chamber formed in one week, 2%	6.6%
Series 2	150 (unselected)	Author's modification of McLean's, one suture	Intracapsular extraction, 67 + 7%†	No chamber at first dressing 5%, formed in one week, 0	4.7%
Series 3 *	35 (unselected)	Author's modification of McLean's, two sutures	Intracapsular extraction, 22 + 3† cases	No chamber at first dressing 2, chamber formed in one week, 1	2 cases

\* Owing to the small number of cases, the incidence of complications is not given in percentages

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# Extraction with Use of Deep Corneoscleral Sutures

Prolapse of Iris and/or Vitreous	Amount of Astigmatism Average	Iritis	Retinal Detachment	Glaucoma	Corneal Dystrophy	Vision, Cases with Extraneous Causes of Poor Vision Excluded
2% (inarceration or tiny prolapse) for two series combined	About 1.50 D  For two series combined					20/30 or better, 88%  (results for two series combined)
1.7%	With one suture, 1.7 D	2.8%	1.3%	2.4%		20/30 or better, 85.7%, less than 20/200, 3.3%
1.2%	With two sutures, 1.4 D	1.4%	0.5%	1.6%		20/30 or better, 91.7%, less than 20/200, 1.9%
1% (?)	About 1.5 D	6% + 5% in eyes with previous uveitis	1%	3% + 3% transient		No selection of cases 20/30 or better, 86% 20/200 or less, 4%
6.6% (iris or vitreous)	1.94 D					
4%	1.82 D					
6.3%	2.56 D					
2.7%	1.32 D					
	Graefe knife, 2.42 D, keratome and scissors, 1.64 D					20/30 or better, 91.8%
7.4%	1.53 D					
	1.5 - 2.5 D					
3.3% vitreous incarcerated, 7.4%	2.13 D	4.0%	1.3%	2.6%	2%	20/30 or better, 91.5% less than 20/200, 3.8%
Inarceration of iris, 3% vitreous incarcerated, 1.3%	2.12 D, uncomplicated cataract, 1.92 D	4.6%	2%	2%	0	20/30 or better, 90.3%, less than 20/200, 3.8%
Vitreous incarcerated, 1 case	1.66 D	0	0	0	0	20/30 or better in 30 out of 31

or the limbus (Lancaster<sup>20</sup>), forming a corneal pocket (Muller,<sup>21</sup> Walker<sup>22</sup>) or a scleral flap (DeVaul,<sup>23</sup> Hymes<sup>24</sup>), in using the conjunctiva to cover the wound (McLean<sup>10</sup>), and in introducing the stitch after the section is completed (Kirby<sup>25</sup>) or rethreading it (Verhoeff) or in introducing it when the section is half completed (Weeks<sup>26</sup>)

It seems less of a risk to put in the suture before the section is made, in order to avoid manipulation with the suture on the opened eye. To place the suture after section, it takes such a highly skilled surgeon as Kirby, who states that he has never had occasion to regret appositional suturing after the section was made. Appositional sutures give a perfect adaptation of the edges of the wound. On the other hand, a suture running over the wound, on the surface of the cornea and sclera, may depress the wound. The wound is well covered, and the nutrition of the cornea is better if there is a conjunctival flap. All these conditions are fulfilled with McLean's suture, which, according to the compilation in the *Green Bulletin*, has the largest number of users. Spaeth<sup>27</sup> acknowledges it as the best one, and Kirby considers it the best preplaced suture.

In 10 consecutive cases in which I used this suture, I found that the reverted conjunctival flap, covering about the upper one fifth or one fourth of the limbus, prevented the surgeon from seeing that portion of the cataract knife which was in the anterior chamber (McLean's figure 1 D<sup>10</sup>). This made it difficult to move the knife in the plane of the limbus. The result was cutting the iris in 3 cases and severing the suture with the knife in 1 case. This difficulty can partially be eliminated by lifting and manipulating the conjunctival flap. This requires a skilful, trained assistant. The difficulty is increased when

20 Roper, K. L. Lancaster's Technique of Cataract Extraction, *Am J Ophth* 26 540, 1943

21 Muller, L. Ein Operationsverfahren für komplizierte Stare und luxierte Linsen, *Klin Monatsbl f Augenh* 41 11, 1903

22 Walker, C. B. Exactly Appositional Sutures in Cataract Operation, *Tr Am Ophth Soc* 27 51, 1929

23 DeVaul, C. H. A New and Improved Method for the Closure of Cataract Incision, *Am J Ophth* 25 1078, 1942

24 Hymes, C. Scleral Flap Incision with Scleral Sutures for the Cataract Operation, *Arch Ophth* 34 374 (Nov-Dec) 1945

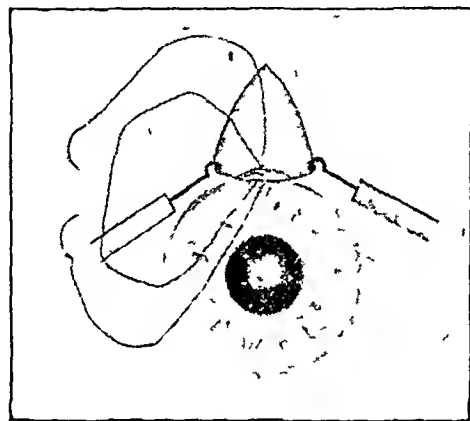
25 Kirby, D. B. Further Experiences with a System of Intracapsular Extraction of Cataract, *Arch Ophth* 31 302 (April) 1944

26 Weeks, C. L. New Corneoscleral Suture Technique, *Arch Ophth* 27 1199 (June) 1942

27 Spaeth, E. B. Principles and Practice of Ophthalmic Surgery, Philadelphia, Lea & Febiger, 1944, p 629

two sutures are used. It was further observed that the suture caused moderate edema of the conjunctival flap, moreover, when the time came to remove it, the mattress suture cut into the conjunctiva which, with such a fine thread and soft tissue, was to be expected.

To avoid these difficulties, the operation was modified in the following way. A vertical incision 8 mm in length is made in the bulbar conjunctiva from the 12 o'clock point on the limbus. The conjunctiva is undermined 3 to 4 mm both nasally and temporally, especially close to the limbus. The preliminary groove is made at the base of the undermined conjunctiva. The Tooke knife proved to be the best instrument for this purpose. The groove is made in the middle of the gray corneoscleral transitional strip, which is about 1 mm wide at the upper portion of the limbus. The incision should penetrate the overlapping scleral tissue and reach actually into the corneal tissue. The appositional suture is introduced at the 12 o'clock position, i. e., correspond-



Deep corneoscleral suture, vertical incision of the bulbar conjunctiva from the 12 o'clock point, with preliminary incision in the middle of the gray transition strip. This incision is made easier by pulling the conjunctiva to the side with hook or forceps. After insertion of the appositional suture, the bulbar conjunctiva is left in its original place. The next step is the Graefe knife incision.

ing to the vertical wound in the conjunctiva. The loop of the thread—only one loop—is pulled to the temporal side (figure). With the conjunctiva in the anatomic position, the incision is easy to perform, and if the preliminary groove is deep enough a good conjunctival flap is gained without severing the preplaced suture. There really will be a nasal and a temporal flap, instead of one flap. The knot will rest on the cornea and sclera and will not interfere with the circulation of the conjunctiva. The same procedure can be used with two sutures, in which case the incisions perpendicular to the limbus are placed at the 11 and the 1 o'clock points, and it is advisable to use a fine conjunctival suture after the corneoscleral sutures are tied to secure the middle flap to the bulbar conjunctiva, which has a tendency to revert over the cornea.

The value of the single suture was tested in a series of 150 consecutive extractions and the value of two sutures in 35 extractions, and the results were compared with those in a series of 150 consecutive extractions in which method A of Verhoeff was used. The two series followed each other chronologically, being interrupted only by the 10 cases in which the original McLean suture was used. All cataract extractions except the linear type were included as they came, both operations for complicated and operations for uncomplicated cataract. It is the complicated cataract which is apt to have more operative and postoperative complications, thus, a technical improvement should show its effectiveness in just such cases. This statistical report is not a large one, but it has the advantage of being based on operations performed by the same surgeon, in two hospitals, where the care of the patients was the same.

Although the value of a suture in the cataract operation shows only after the suture is tied, it is proper to give the operative steps in a few words. Van Lint akinesia of the orbicularis muscle, suture fixation of the superior rectus muscle, vertical incision of the conjunctiva at the 12 o'clock point, undermining of the conjunctiva, placement of a groove in the limbus, insertion of the suture, section with the Graefe knife and securing of fairly large nasal and temporal conjunctival flaps, complete or peripheral iridectomy, grasping of the capsule 2.5 mm below the anterior pole with the Arruga or Imre capsule forceps, and exertion of 50 per cent pull and rotation and 50 per cent push from below with the Imre half-ring instrument (named the Budapest instrument by Guyton). In most cases the lens will tumble. In patients older than 75, the capsule is caught above the anterior pole, and the lens is not tumbled. If the capsule breaks, a new grasp is sought and an attempt made to complete the intracapsular extraction. In cases of extracapsular extraction, after the delivery, the cornea is slightly lifted with the help of the suture, and the edge of the capsule is caught as far down in the pupillary area as possible. This measure is omitted only if the vitreous is bulging menacingly. The suture is tied, but not so tightly as to cause a furrow in the cornea, the iris reposer is always used, followed by a careful inspection of the wound, to ascertain especially the position of the conjunctival flaps. Physostigmine ointment is given in cases of round pupil extractions and intracapsular extraction, and a binocular bandage is placed for twenty-four hours. On the next day the bandage of the fellow eye is removed, and the patient may sit up in a chair. The suture is removed on the eleventh day.

From this point, the type of suturing may determine how the wound heals, and the suture is in part responsible for the postoperative complications and for the amount of astigmatism. However, there are

several other factors at play, to mention only the most important ones the site of the wound, round pupil extraction or complete iridectomy, intracapsular or extracapsular extraction, occurrence of infection during operation and after-care

The number of intracapsular and of round pupil extractions is given in table 2

TABLE 2—*Distribution of Intracapsular Extractions and Peripheral Iridectomies in the Three Series*

	Number of Cases	Intracapsular Extraction	Capsule Torn, Removed in Toto	Peripheral Iridectomy
First series	150	89	23	0
		112 (74.6%)		
Second series	150	103	11	12
		114 (76%)		
Third series	35	22	3	1
		25 (71.4%)		

#### COMPLICATIONS OF WOUND HEALING

*Delayed Refilling of the Anterior Chamber*—This complication indicates that the wound is not closed. The anterior chamber was flat twenty-four hours after the operation in 16 cases in the first series (Verhoeff's method A), but in only 3 of these was the chamber not refilled at the end of one week. In the second series (new suture) the corresponding figures were 8 and 0, respectively. When two sutures were used, there was only 1 case with no chamber for a few days. Equally revealing are the figures when the duration of the shallowness of the chamber is examined.

The period during which the anterior chamber remained shallow is tabulated

No. of Days	Series		
	I	II	III
2	4	6	1
3	7	4	1
4	3		
5	2	2	
6	3	1	
7	3	1	1
8	1		
21	1		
	24 (16%)	14 (9.3%)	3 (8.6%)

These figures show that all cases with the new suture had a chamber of normal depth in seven days.

It is difficult to compare these data with those of the other publications. For example, McLean gives figures for delayed formation of the anterior chamber, Leech and Sugar, for absence of the chamber at



the first dressing, and Hughes and Owens,<sup>28</sup> for incòplete closure of the wound. These conditions are evidently not exactly the same.

*Hemorrhage in the Anterior Chamber*—Hemorrhage in the chamber is almost always due to reopening of the wound after new capillaries have formed. However, in diabetes there is a tendency to hemorrhage from the iris, according to Philps.<sup>29</sup> Collins<sup>30</sup> gave microscopic evidence that there are young blood vessels in the wound on the third day, and it is known that hyphema usually occurs on the fourth to the sixth day. Vail<sup>31</sup> emphasized the importance of trauma in the majority of cases of hyphema but stated that increased intraocular pressure from rapid filling of the anterior chamber is a predisposing factor. Neff<sup>32</sup> found that trauma, at a critical time, was instrumental in causing hyphema and that the constitutional background of the patient had a definite significance. Vail found from the statistics of 17 authors that the average incidence was 7.9 per cent. When these series were studied, deep sutures had not yet been used.

Even with conjunctival sutures the incidence of hemorrhage in the anterior chamber was 9.2, 11.3 and 18.7 per cent, respectively, in the series of Davis,<sup>8</sup> Leech and Sugar<sup>9</sup> and McLean.<sup>10</sup> The site of the wound is also a factor. The more the wound is limited to the cornea, the less is the incidence of hyphema. All in all, hyphema is a fairly good indicator of the effectiveness of the suture. But, as Hilding<sup>33</sup> put it, safe closure is a relative term, there is no suture which can resist any amount of force. The incidences in my three series were 6.6, 4.7 and 5.7 per cent, respectively. The lowest figures are those of Stallard, with no hyphema in 107 cases (but Leech and Sugar, using the same suture, had an incidence of 4.6 per cent, of McLean, with 3.6 per cent, using one suture, of Hughes and Owens, with 4.6 per cent, using one or two sutures, and of Roper,<sup>29</sup> with 3.7 per cent, using two or three sutures).

*Prolapse of the Iris*—This complication, occurring in the first days after operation, reveals a violent, sudden opening of the wound. Prolapse of the vitreous belongs in the same category, it usually is associated with incarceration of the iris. Late subconjunctival prolapse of the iris develops gradually, and, as Klem pointed out, the prognosis is serious.

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28 Hughes, W. F., and Owens, W. C. Extraction of Senile Cataract, *Tr Am Ophth* **49** 251, 1945.

29 Philps, A. S. Post-Cataract Hyphema, *Brit J Ophth* **24** 122, 1940.

30 Collins, E. T., cited by Philps.<sup>29</sup>

31 Vail, D. Hyphema After Cataract Operation, *Am J Ophth* **24** 920, 1941.

32 Neff, E. E. Factors Affecting Hemorrhage Following Extraction of Cataract, *Arch Ophth* **33** 192 (March) 1945.

33 Hilding, A. C. Experimental and Clinical Studies in Certain Safety Factors in Closure of Cataract Incisions, *Am J Ophth* **28** 871, 1945.

The incidence of prolapse of the iris in my first and second series was 3.3 and 1.3 per cent, respectively, but there was incarceration of the vitreous in 7.3 and 1.3 per cent, respectively. Hilding had prolapse of the iris in 5 per cent of his second series, with four sutures but without iridectomy. From the diagrammatic representation of the final shape of the pupil in his 184 cases, 6.8 per cent had a more or less drawn-up pupil, and 16.5 per cent had complete iridectomy, his paper proving that round pupil extraction cannot be used in an unbroken, unselected series. No doubt the round pupil extraction with peripheral iridectomy or iridotomy is the ideal method. The best visual results and the least complications were obtained in the cases of peripheral iridectomy and intracapsular extraction of Hughes and Owens, but this series is a selected material, after elimination of the cases of complicated cataract, the cases with broken capsule and the cases in which iridectomy had to be performed for some reason. Kriby saved the sphincter in 52 per cent. This, it seems, is close to the maximal percentage in which round pupil extraction with peripheral iridectomy can be performed without undue risk of prolapse of the iris or of drawing up of the pupil. Of his 100 cases, 62 were considered fit for round pupil extraction, but in 10 of these complete iridectomy had to be done.

It does not seem to make any difference which type of deep, appositional suture is used in the prevention of postoperative prolapse of the iris. But even several deep sutures do not prevent the drawing up of the pupil if no peripheral iridectomy is done.

*Other Complications of Wound Healing*—Such complications as eversion of the cornea, gaping or unevenness of the wound or fistula in the wound should not occur with deep sutures, or should occur only when excessive force is applied to the eye.

*Postoperative Astigmatism*—The amount of astigmatism indicates the deformity of the cornea due to the wound. Several factors determine its amount, among which are the length and the site of the wound. A scleral wound is followed by more astigmatism than a corneal one. The cornea is more apt to regain its normal curvature than is the sclera. On the other hand, when the cornea is stretched, as in loop extraction or eversion of the cornea, there will be more astigmatism. A tangential wound through the cornea probably causes more astigmatism than a perpendicular one. O'Brien<sup>34</sup> made a valuable contribution to this point. In one half of an unselected series of 220 cataract extractions he used the Graefe knife, in the other half, the keratome and scissors. The average incidences of astigmatism were 2.42 and 1.64 D, respectively, with six episcleral sutures.

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<sup>34</sup> O'Brien, C. S. Comparison of the Keratome-Scissors and the Graefe Knife Incisions for Cataract Extraction, *Am J Ophth* 26:504, 1943.

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34 O'Brien, C. S. Comparison of the Keratome-Scissors and the Graefe Knife Incisions for Cataract Extraction, *Am J Ophth* 26:504, 1943.

In my three series the average amounts of astigmatism were 2.3, 2.09 and 1.66 D, respectively. In each series about one-half the patients were examined only once, about seven weeks after operation, when the final refraction was done. The other half were examined again in four to twelve months. These values, 2.32 and 2.09 D, are higher than those of the other authors who used deep sutures (1.32 to 1.82 D). The series of Hughes and Owens carries perhaps the most weight, because of the large number of cases. They had 1.7 D when one suture, and 1.4 D when two sutures, were used. However, the cases of complicated cataract and extracapsular extraction were excluded. If this was done in my second series (in which one suture was used), the average amount of astigmatism would be 1.92 D. Eighteen of my patients had operation for cataract on both eyes, on one eye the single suture and on the other eye two sutures were used, the average amounts of astigmatism were 1.81 and 1.42 D, respectively, for the two eyes. Thus, when two deep sutures were used, the postoperative astigmatism was 0.3 to 0.4 D less than that when one deep suture was used. Compilation of the data from the literature shows that with one deep suture the astigmatism was from 1.50 to 2.00 D and with two deep sutures from 1.4 to 1.5 D. Only McLean's series is an exception, 99 cases with 1 suture and 11 cases with two sutures gave an average of 1.32 D.

#### OTHER POSTOPERATIVE COMPLICATIONS

*Postoperative Iritis*—This complication is almost exclusively caused by primary infection, therefore it cannot be expected that the suture would decrease its incidence. The intracapsular extraction was an important step in this direction by not leaving behind any lens matter, which is a good medium for most of the bacteria of the conjunctival sac. Iritis occurred in 4 and 4.6 per cent, respectively, of two series and in none of the third series. In half these eyes there had been some previous intraocular disease.

In the series of the other authors the incidence of iritis varied from 1.4 to 6 per cent.

*Postoperative Ablatio Retinae*—It is improbable that the type of suture has any effect on the incidence of postoperative detachment of the retina. This is determined by factors present before the operation, such as predisposition, accidents which occurred during the operation, such as loss of vitreous, and changes which occurred in spite of the suture after the operation, such as adhesion of the vitreous to the wound. The important, and unsettled, question is whether the intracapsular or the extracapsular method is followed more often by detachment. This is not the subject of this paper. Detachment of the retina occurred in 2 instances in the first series, in 3 instances in the second series and in none in the third series. In all 5 cases it

followed intracapsular extraction with no loss of vitreous. In Knapp's 500 cases of intracapsular extraction there were 6 instances of detachment, in only 1 of which it followed loss of vitreous. Hughes and Owens had detachment in 0.9 per cent of 1,720 extractions, both intracapsular and extracapsular, in which no vitreous was lost. However, as they convincingly proved, the incidence of detachment increases in proportion to the amount of loss of vitreous to reach 10.9 per cent after extractions with severe loss of vitreous.

*Glaucoma*—It is generally accepted that incarceration or prolapse of the iris or the vitreous, iritis, hyphema of long duration—factors leading to partial blocking of the angle of the chamber—are usually responsible for postoperative glaucoma. Kronfeld and Haas<sup>35</sup> clearly proved that a single factor, the delayed formation of the chamber, can lead to enough peripheral anterior synechias to produce glaucoma in previously normal eyes. However, it is not known how much pathologic change is needed in a given case to upset the anatomic relations and the forces regulating the tension. The suture is instrumental in reducing all those factors mentioned which predispose to glaucoma. The various statistics in regard to this complication are hard to evaluate and to compare, because this type of glaucoma may manifest itself only several months, or years, later. Besides it usually does not cause pain, so the aged person does not seek medical aid in every instance. The usual statistical figure is between 1 and 3 per cent. In my first, second and third series the corresponding figures were 4 (2.6 per cent), 3 (2.0 per cent) and 0. In the first series there was prolapse of the iris in 2 cases, prolapse of the vitreous in 1 case and loss of vitreous during operation in 1 case. In the second series glaucoma existed before the extraction in 2 cases, in the third case there were loss of vitreous and loop extraction.

*Dystrophy of the Cornea*—This complication of the cataract operation is rare. It is not amenable to any treatment and usually results in very poor vision or in blindness. Terry<sup>36</sup> set up five types of corneal changes which result in unsuccessful cataract operation. To group 4 belong "lesions arising through stimulation of degeneration or production changes resulting directly or indirectly from the operation, such as exacerbation of corneal dystrophy." Fuchs<sup>37</sup> found this condition in more acute form after irrigation of the anterior chamber, even when isotonic solution of sodium chloride was used. The slower-developing

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35 Kronfeld, P. C., and Haas, J. S. Glaucoma Due to Peripheral Anterior Synechia After Operation for Cataract, *Arch. Ophth.* **33** 199 (March) 1945.

36 Terry, T. Unsuccessful Cataract Extractions, *Arch. Ophth.* **29** 862 (May) 1943.

37 Fuchs, E. Erkrankungen der Hornhaut durch Schädigungen von hinten, *Arch. f. Ophth.* **92** 145, 1916.

type occurred when more than one operation had to be performed. The diffuse corneal haziness was superficial at first, and vesicles appeared, finally, a condition which he called sclerosis of the cornea, similar to epithelial dystrophy of the cornea developed. Fuchs made histologic examination in 10 such cases and observed lamellar layering on the anterior surface, swelling and wrinkling of the corneal lamella, hyaline degeneration and homogenous layering on the posterior surface.

In my first series there were 3 such cases, with none in the second and third series.

A typical case is that of Mrs. P. E., aged 79, who was first seen Feb. 10, 1939. In November 1938 she underwent a cataract operation on the left eye and, a few weeks later, two operations for glaucoma on the same eye. Vision was equal to counting fingers at 4 feet (120 cm) in the right eye, and light perception and projection were good in the left eye. In the right eye there were a fine central corneal macula 2 mm in diameter and diffuse blur of the nucleus of the lens. Tension was normal. The left eye was aphakic, the cornea was cloudy in the deep layers, and a vitreous hernia was touching the cornea. On Aug. 14, 1940, vision in the left eye was equal to light perception and light projection, and tension was +2. There was a deep ulcer of 2.5 mm diameter in the center of the cornea, the chamber was one third filled with blood. The corneal ulcer cleared up. On May 20, 1943, intracapsular extraction was done on the right eye, with little pressure applied, the Verhoeff suture was employed, recovery was uneventful, but striate keratitis was pronounced. On July 10, 1943, vision in the right eye was 20/200 with correction. There was moderate haziness in front of Descemet's membrane in the central portion of the cornea. Instillation of an ointment containing 5 per cent ethyl morphine hydrochloride and warm packs were ordered. The haziness became deeper, and by Aug. 8, 1945, vision had fallen to counting fingers at 2 feet (60 cm). The cornea became stippled and hazier, with gradual involvement of the anterior layers, and an occasional vesicle and bulla caused severe pain. Removal of the epithelium and treatment with zinc sulfate, 0.5 per cent, for two minutes was effective against the recurrence of the bullous keratitis. Tension in the left eye remained normal all the time. In this case corneal dystrophy followed the cataract operation in both eyes. It can be assumed that this patient had a predisposition to dystrophy.

I observed this condition in a total of 5 eyes in 4 patients in the course of 500 extractions. In 1 patient (see preceding paragraph) it developed in both eyes, in the other 3 patients, in one eye. The probable contributing factors were old central macula, prolapse of the iris, with attempted reposition and excision, prolonged massage to remove cortical matter, and two operations for glaucoma following the extraction. In all cases there were numerous folds in Descemet's membrane, and the corneal opacity started in the deep layers and gradually advanced toward the epithelium. Finally, in one-half to two years, the epithelium became involved and vesicles appeared. Glaucoma developed later in 1 case.

From this experience with postoperative dystrophy of the cornea, it is evident that it occurs in eyes which either show a visible pathologic

process of the cornea or, as Fuchs and Terry suggested, have a latent predisposition to dystrophy, which becomes evident after the eyes have undergone more than one operation. In most cases probably there is damage to the endothelium and Descemet's membrane, either direct or indirect. To quote Kirby,<sup>38</sup> "If healing of the breach [in the endothelium] does not occur, dystrophy and bullous keratitis may develop."

It does not seem probable that the use of any type of suture has a prophylactic influence on this condition. It should be noted, however, that in all my 3 cases there was no conjunctival flap. Is this a contributing factor to the dystrophy because of poorer nutrition of the cornea?

*Expulsive Hemorrhage*—Expulsive hemorrhage, with so much preoperative precaution, is rare nowadays. It is fair to assume that late expulsive hemorrhage, which occurs several hours or days after the operation, is prevented by the deep suture. In the prophylaxis of another late complication, changes in the vitreous, which is secondary to loss of vitreous, I should not attempt to determine the value of the suture.

TABLE 3—Visual Results

Series	Visual Acuity				Number of Cases with Preoperative Complications Which Were Omitted *
	20/15 to 20/30	20/40 to 20/70	20/100 to 20/200	Less than 20/200	
First	118 91.5%	6 4.7%	0	5 3.8%	21
Second	112 90.3%	8 6.5%	0	4 3.2%	26
Third	30	1	0	0	4

\* However, in about one half of these cases normal vision was regained.

#### VISUAL RESULTS

The visual results (table 3) can be correctly compared only if the cases with extraneous causes of reduced vision are excluded. There were 21 such cases in the first series, 26 in the second series and 4 in the third series. These were cases of corneal scar, conical cornea, changes due to uveitis, various types of retinopathy, senile macular degeneration, severe myopic changes in the fundus, amblyopia and glaucoma.

In the first paragraph of this paper the statement was made that the postoperative infection is second in importance to the other types of postoperative complications. How does this statement hold in the light of my 335 cases, which number includes all cases of complicated cataract? Final vision was less than 20/200 owing to iritis in 3 cases;

38 Kirby, D. B. Prevention and Handling of Complications Arising During and After Cataract Extraction, Arch. Ophth. 25:866 (May) 1941.



1 of these eyes was enucleated Vision was less than 20/200 as a result of retinal detachment or of corneal dystrophy in 3 cases each, and of glaucoma, of condensation or of blue vitreous in 1 case each, 1 e, vision was less than 20/200, definitely poor, as a result of operative or postoperative complications of inflammatory nature in 3 cases and of a noninflammatory nature in 8 cases

#### SUMMARY

Use of deep sutures in cataract operations is a great step forward in eliminating certain complications The preplaced appositional corneoscleral suture, combined with a conjunctival flap covering the wound, is considered the best method A modification of the McLean suture is described which eliminates the difficulty of making the wound in the presence of a prepared conjunctival flap One or two sutures can be used A series of 150 unselected cases of cataract extraction with use of the Verhoeff suture, method A, and a second series of 150 cases of extractions with use of the new suture are compared as to postoperative complications, degree of astigmatism and final visual results In a third series, of 35 unselected cases, two sutures were used Complications and results obtained by other authors using deep sutures and those in two series with the use of conjunctival sutures are tabulated

It was found that the new suture was superior to the Kalt-Verhoeff suture in the rapid and solid closing of the wound, thus keeping low the incidence of shallow and flat chambers, wound rupture and postoperative prolapse of the iris and vitreous However, in this respect it was not better than the original McLean suture, it was only easier to carry out The postoperative astigmatism was about 0.3 D higher than it was with the McLean suture When two sutures were used, the astigmatism was about the same as that with two McLean or three appositional sutures

The visual results compare favorably with the statistics of other authors In both series of extractions 20/30 vision or better was obtained in 90 per cent of the cases of uncomplicated cataracts Among the late postoperative complications, detachment of the retina and corneal dystrophy are believed not to be reduced by the suture The latter condition occurred only in cases in which no conjunctival flap was made The incidence of glaucoma is reduced indirectly by the suture through reduction in the complications of closure of the wound However, this has not been shown by my figures With careful preparation and the intracapsular technic, employment of deep sutures and use of the sulfonamide drugs or penicillin, the postoperative infection is less often the cause of poor results than are the other postoperative complications taken as a group

# OCULAR INVOLVEMENT IN RATS ON DIETS DEFICIENT IN AMINO ACIDS

## I Tryptophan

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**O**CULAR involvement and cataractous changes in the lens have been reported under a great number of experimental conditions (tetany, diabetes, including galactose and xylose cataract, thallium intoxication, riboflavin deficiency) and clinically in association with various cutaneous diseases, as well as with mongolism and myotonia <sup>1</sup>

More recently, blindness with opacities of the lens was described by Curtis and associates,<sup>2</sup> and cataractous changes in the lens with vascularization of the cornea were reported by Totter and Day,<sup>3</sup> Albanese and Buschke <sup>4</sup> and Buschke <sup>5</sup> in rats on tryptophan-deficient diets

During the past four years we have been studying the effects of various amino acid-deficient diets on the growth, development, morphology of various body tissues and organs, endocrine glands and nervous system in rats. Up to the present we have observed ocular involvement with diets deficient in tryptophan and valine

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Read at a meeting of the New York Society for Clinical Ophthalmology, May 7, 1945

From the Department of Neuropathology, New York State Psychiatric Institute and Hospital

1 Buschke, W Dystrophic Cataracts and Their Relation to Other "Metabolic" Cataracts, *Arch Ophth* **30** 751 (Dec) 1943

2 Curtis, P B, Hauge, S M, and Kraybill, H R The Nutritive Value of Certain Animal Protein Concentrates, *J Nutrition* **5** 502, 1932

3 Totter, J R, and Day, P L Cataract and Other Ocular Changes Resulting from Tryptophane Deficiency, *J Biol Chem* **140** 136, 1941

4 (a) Albanese, A A, and Buschke, W On Cataract and Certain Other Manifestations of Tryptophane Deficiency in Rats, *Science* **95** 584, 1942 (b) Albanese, A A Corneal Vascularization in Rats on Tryptophane Deficient Diets, *ibid* **101** 619, 1945

5 Buschke, W Classification of Experimental Cataracts in the Rat Recent Observations on Cataract Associated with Tryptophan Deficiency and with Some Other Experimental Conditions, *Arch Ophth* **30** 735 (Dec) 1943

In rats on a tryptophan-deficient diet we were able to confirm and to extend the observations of some of the aforementioned authors<sup>6</sup> In the present paper, particular attention will be paid to the development and the histologic character of the cataractous changes in the lens associated with this deficiency

#### EXPERIMENTAL PROCEDURE

In all, 89 young (45 to 55 Gm), adult (100 to 120 Gm) and older (200 Gm) albino rats of the Sherman strain, of the same litter and sex (male), were used in these experiments

The animals were separated into four groups The first group of rats was fed a tryptophan-deficient diet as suggested by Albanese and co-workers except that (1) the vitamin mixture was administered according to the method of Riess and Block and (2) the salt fixture was prepared according to Huvell and associates<sup>7</sup>

The other three groups of rats, used as controls, were divided as follows Group 2 was fed the same tryptophan-deficient diet as the rats in group 1, modified only by the addition of synthetic tryptophan from the beginning of the experiments, group 3 was maintained on the tryptophan-deficient diet until definite signs involving the ocular structures were apparent, and then synthetic tryptophan was added to the diet, group 4 was fed a standard normal diet for rats (Rockland's rat pellets) to which hydrosoluble and liposoluble vitamins were added in the same amount and form

Two additional control groups of rats fed with a tryptophan-deficient diet supplemented with excess of vitamin A and riboflavin, respectively, were also used These controls were intended to eliminate the possible influence of vitamin deficiencies in determining the cataractous changes

The rats were killed with ether at various stages of the experimental investigation Some were maintained alive for about eighteen months and then killed However, some died unexpectedly Autopsy was performed immediately after death, and the tissues were fixed by microinjection technic with a 5 per cent concentration of solution of formaldehyde U S P in isotonic solution of sodium chloride or in 80 per cent alcohol For the histologic studies of the lens, pyroxylin embedding was used, and serial sections were stained with hematoxylin and eosin, the Van Gieson stain and the Masson method

#### EXPERIMENTAL OBSERVATIONS

Most of the animals on tryptophan-deficient diets disclosed, in various degrees, arrest of growth, loss of body weight, changes in the general appearance (hunched posture), disappearance of the subcutaneous adipose tissue, pronounced pallor of the skin and visible mucosa, alteration of fur (thinning, fragmentation and alopecia), atrophy of the gonads and, at times, yellowish coloring of the incisor teeth with alteration of the enamel

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6 Totter and Day<sup>3</sup> Albanese and Buschke<sup>4a</sup> Buschke<sup>5</sup>

7 Details on diets will be reported in a subsequent paper, dealing with histologic changes in various organs occurring with tryptophan-deficient diets

The ocular changes, in order of their appearance, may be described as follows. Pronounced superficial vascularization of the cornea, at times followed by or associated with spectacle eyes. The latter was characterized by complete loss of fur on the eyelids and, to a less extent (fig 1 *A*), extreme edema and congestion of the eyelids (fig 1 *B*), conjunctivitis, and the presence of catarrhal and mucous secretion around the eyelids, causing at times adherence and complete occlusion of the eyelids (fig 1 *C*) unless treated with a medicamentous or saline solution. These changes appeared four to six weeks after the beginning of the experiments in the younger animals (45 to 55 Gm.)

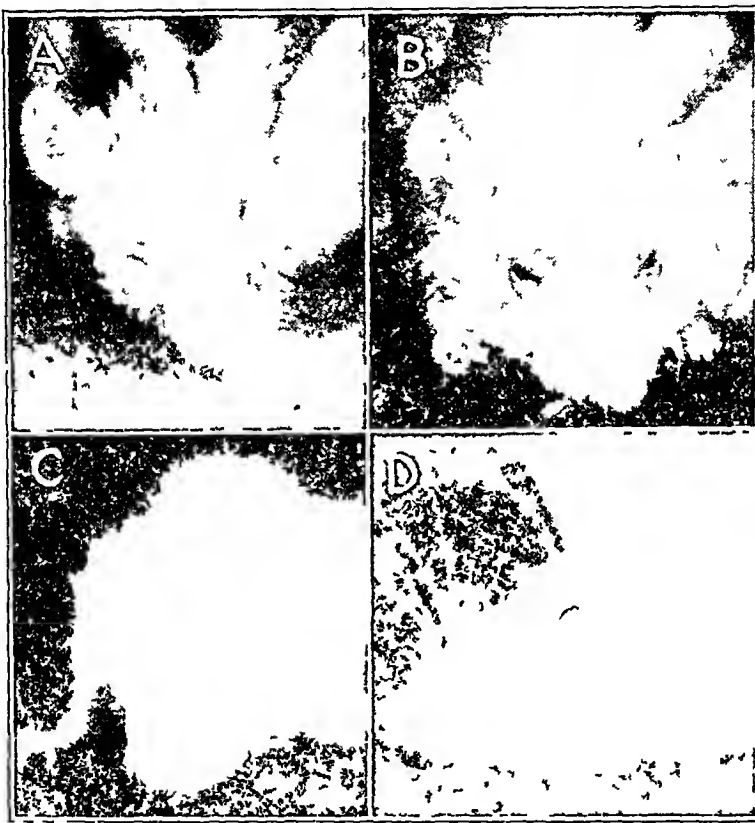


Fig 1—*A* and *B*, extreme edema of the eyelids and spectacle eyes, *C*, adherence and complete occlusion of the eyelids, due to catarrhal secretion, *D*, normal control rat

In the more developed animals, weighing 100 to 120 Gm (at the beginning of the experiments), gradual development of opacities of the lens was noticed within five to eleven weeks after the beginning of the experiments (figs 2 and 3)

During the lifetime of the animals Dr Isadore Givner examined all the eyes with the slit lamp, both before the rat was placed on the deficient diet and weekly thereafter. In addition, the eyes were explored with the binocular loupe and with the ophthalmoscope for details of the fundus. All eyes were dilated to the maximum with a 1 per cent

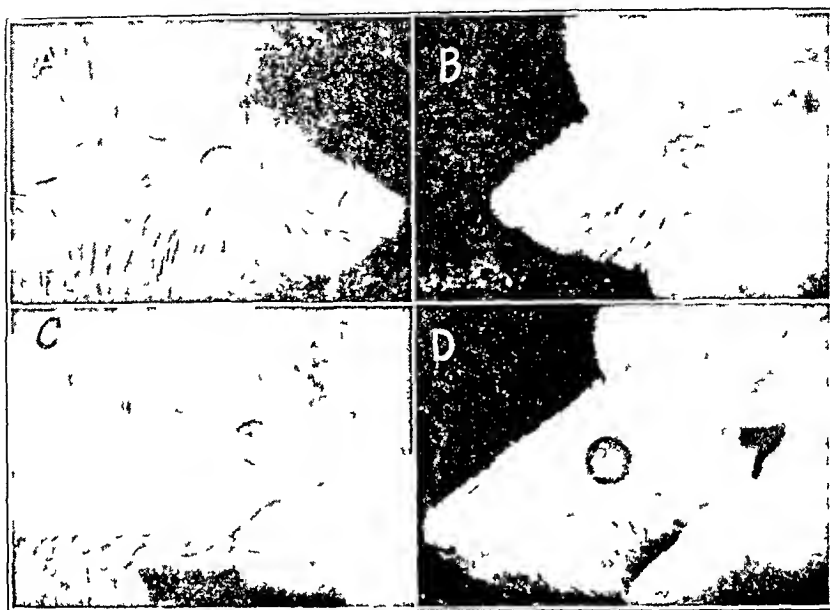


Fig 2—Opacities of the lens in different rats

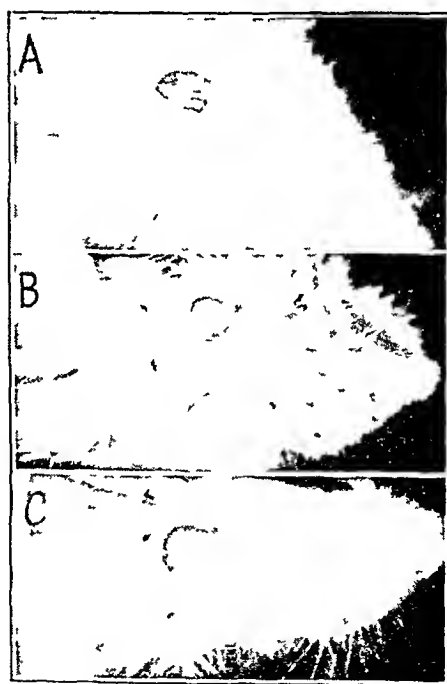


Fig 3—*A*, early changes in transparency of the lens, *B*, complete cataractous changes in the lens, *C*, lens of a normal control rat

solution of homatropine hydrobromide. Ophthalmoscopic examination revealed "some cataractous changes," at times involving only one eye and at others both, although always in various degrees. It seemed that the variability was not alone the expression of individual susceptibility

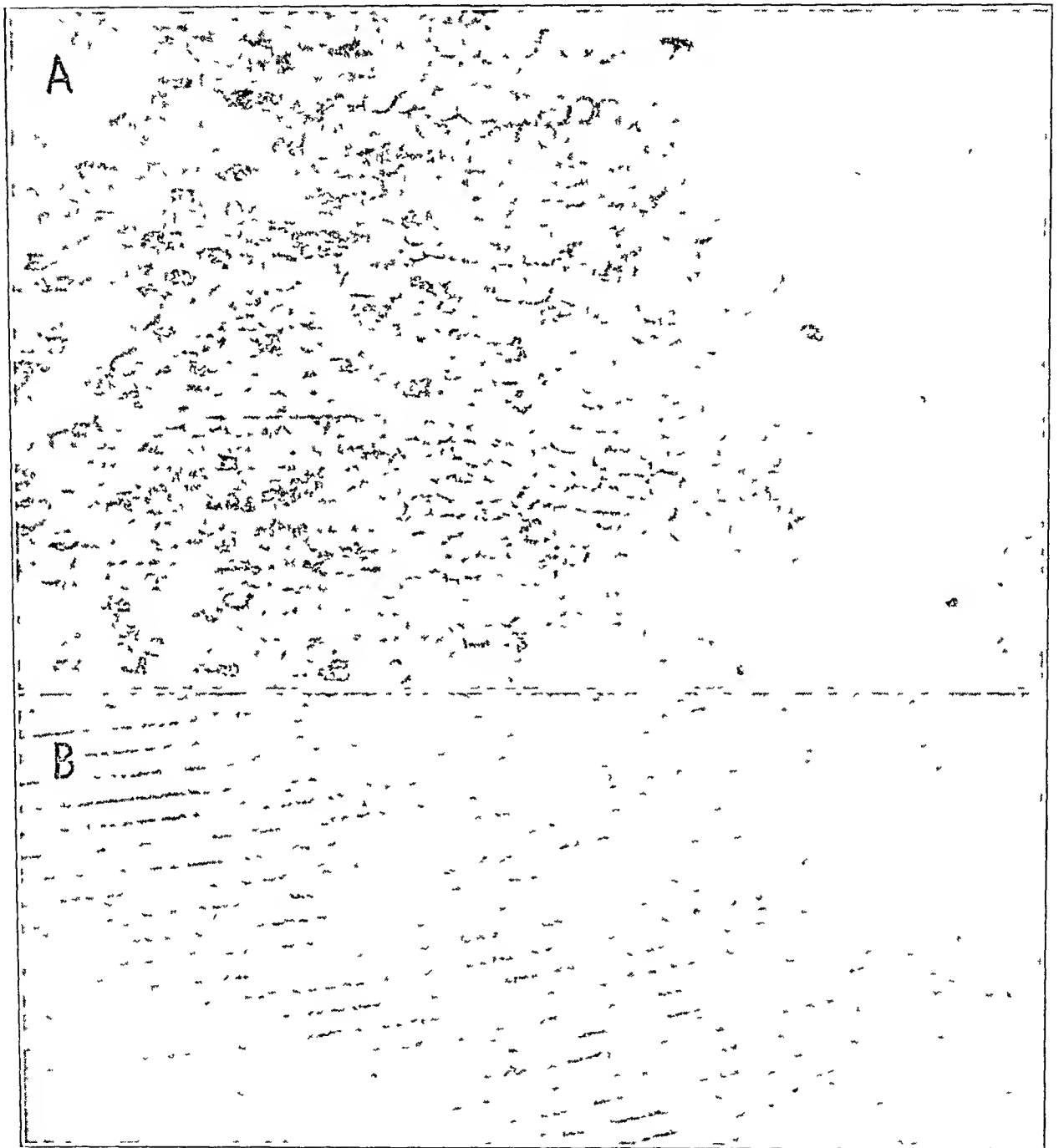


Fig 4—*A*, vacuolar degeneration of the lens fibers, *B*, section of the lens of a normal control rat. Hematoxylin-eosin stain, medium power magnification

to the pathologic process of rats of the same litter, inasmuch as variability was noticed in the eyes of the same animal when both were involved.

In general, approximately 65 to 70 per cent of the animals disclosed various types and degrees of cataractous changes in the lens.

Microscopic studies revealed that some of the earlier changes involved more frequently the cortex of the lens. At this stage they consisted mostly of water splitting of the lens fibers and vacuolar formations, which at higher magnification were seen clearly, usually within the fibers themselves (fig 4*A*). The vacuoles were often numerous and closely pressed together, so that the structure resembled a threadlike alga or degenerating myelin in nerve fibers.

At later stages severer morphologic changes, leading at times to complete degeneration and disintegration of the lenticular structures, were observed. These changes involved to different degrees the various parts of the lens, such as the cortical, the perinuclear or the nuclear, or various combinations of these (figs 5*A, B, C* and *D*). While at times

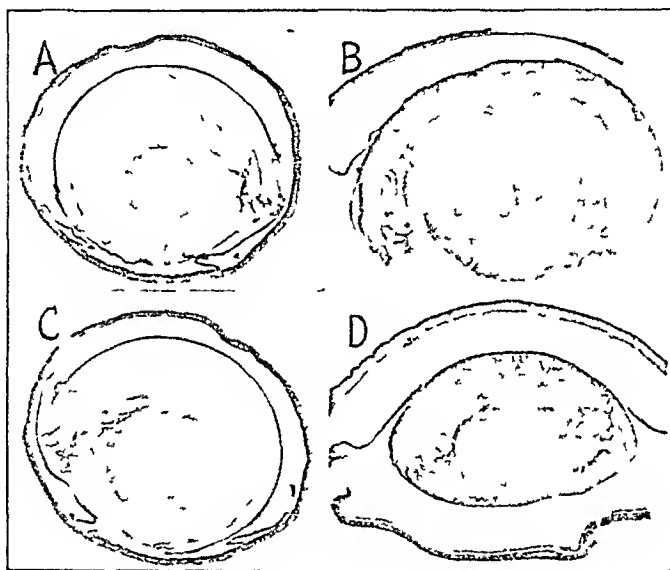


Fig 5—*A, B, C* and *D*, cataractous changes involving, in various degrees, different parts of the lens, as described in the text. *A* and *C*, Van Gieson stain, *B* and *D*, hematoxylin-eosin stain, low power magnification.

the morphologic alterations were distributed in layers, lamellas or more or less concentric or patchy formations (fig 6*A* and *B*), in other instances complete disorganization and disruption of the histologic structure were evident (fig 7*A* and *B*).

In group 3 the rats were maintained on a tryptophan-deficient diet until definite signs involving the various ocular structures were apparent, and then synthetic tryptophan was added to the diet. Within two to four weeks after administration of the synthetic tryptophan, gradual improvement in the general condition of the animal, new growth of fur in the alopecic areas, progressive gain in weight and slow increase in size of the gonads to an almost normal appearance were noted.

Concomitantly, some of the ocular manifestations improved considerably. The spectacle eyes and conjunctivitis disappeared in three to four and a half weeks, and the external appearance of the eyelids and eyes assumed that of the control animals (figs 8 and 9). The vessels of the cornea narrowed and became empty of blood, and some were

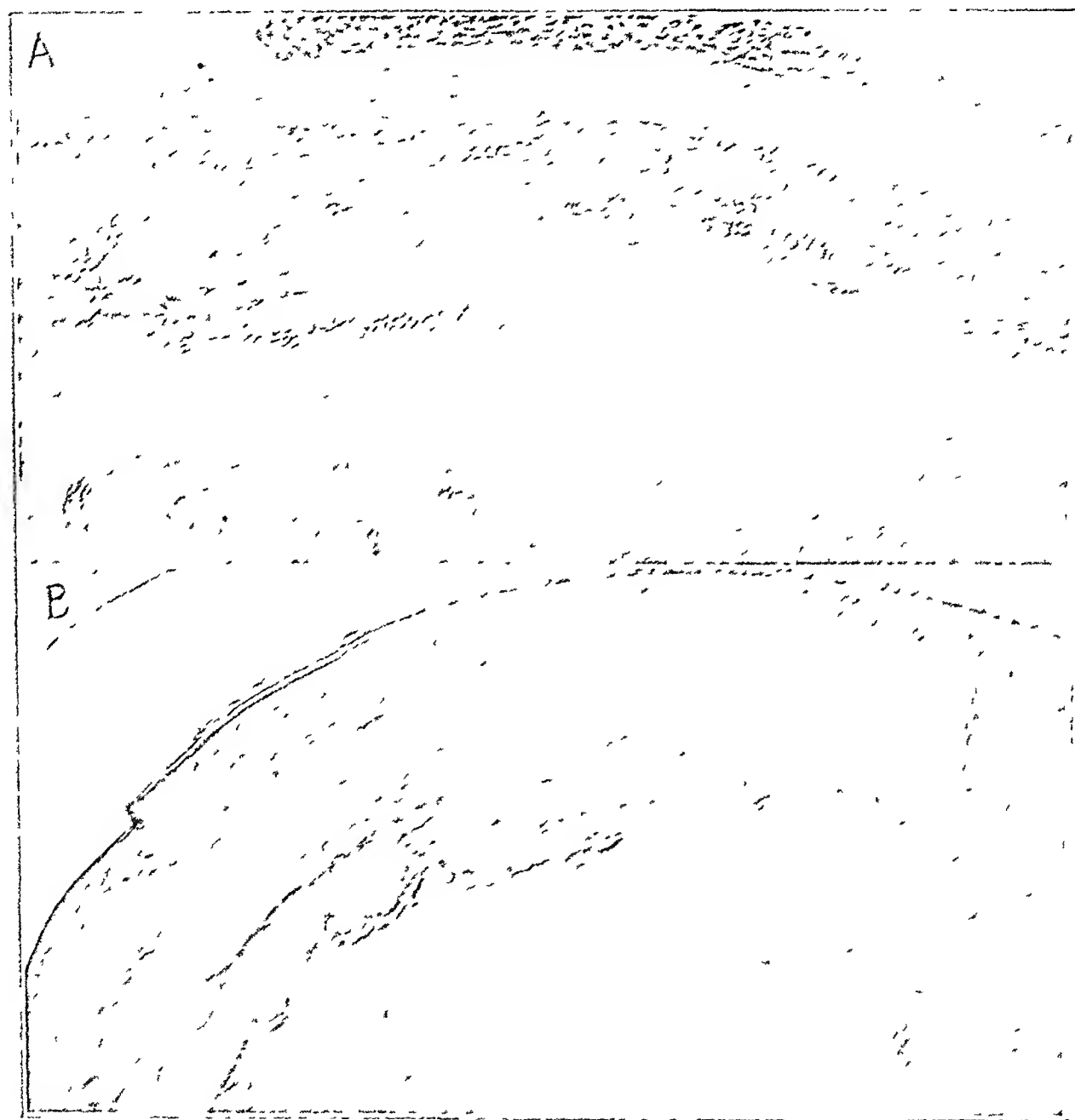


Fig. 6.—Distribution of the morphologic alterations of the lens in (A) normal and (B) concentric-like formation. Hematoxylin-eosin stain, moderate power magnification.

found only with the aid of transillumination. The cataractous changes improved, and in some cases the water splitting of the anterior or the posterior cortex or of both disappeared completely. Examinations with



the slit lamp showed that opacification was definitely less, and with the ophthalmoscope details of the fundi could be visualized which could not be seen before the addition of synthetic tryptophan to the diet

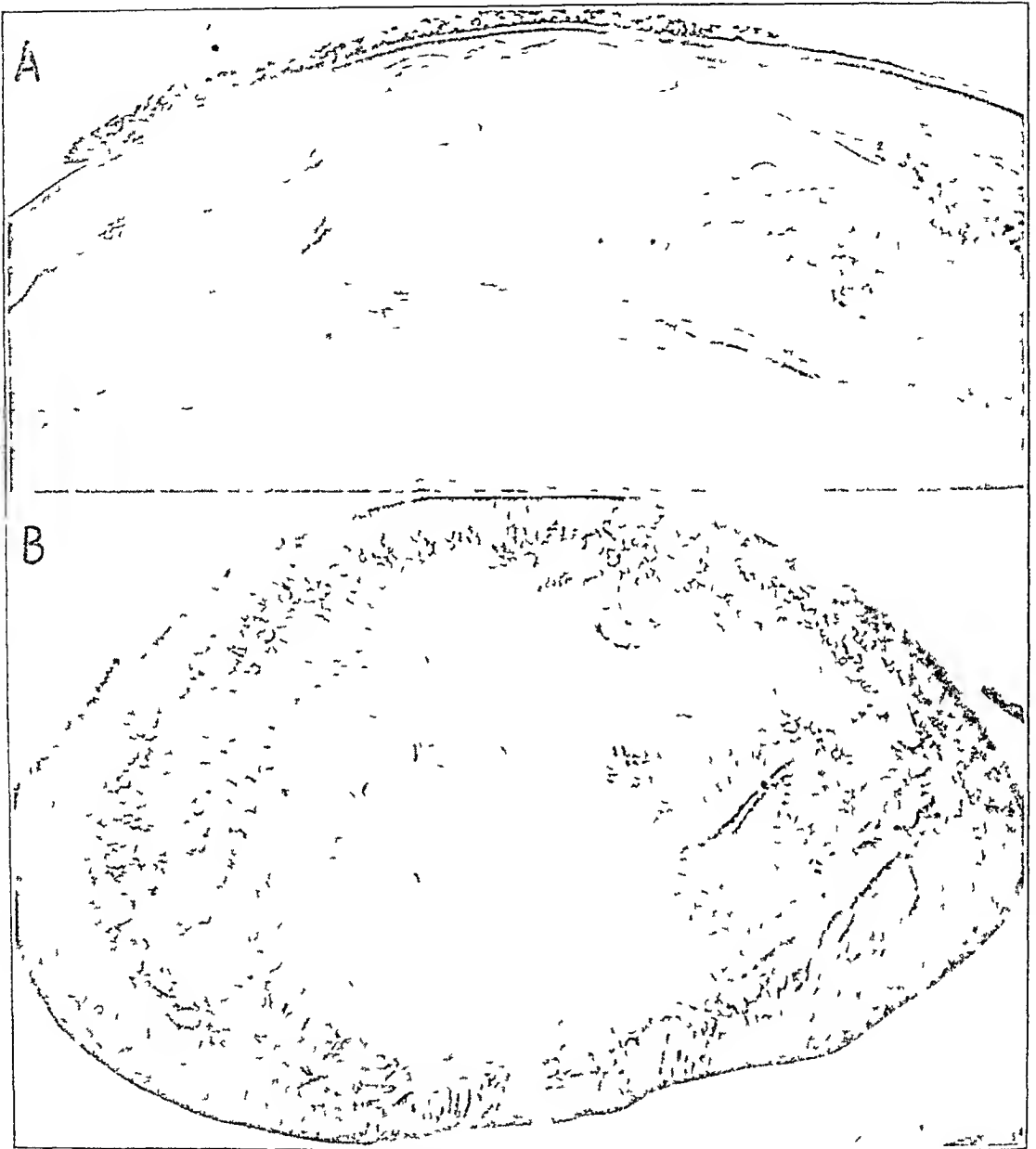


Fig 7—(A) large patch and (B) total disorganization of the histologic structure of the lens. Hematoxylin-eosin stain, low power magnification

However, some of the more advanced cataractous changes (approximately at the stage illustrated in figures 5, 6 and 7) did not react favorably. In some cases the improvement was slight, and in others it did not occur at all. In animals in which definite cataractous changes

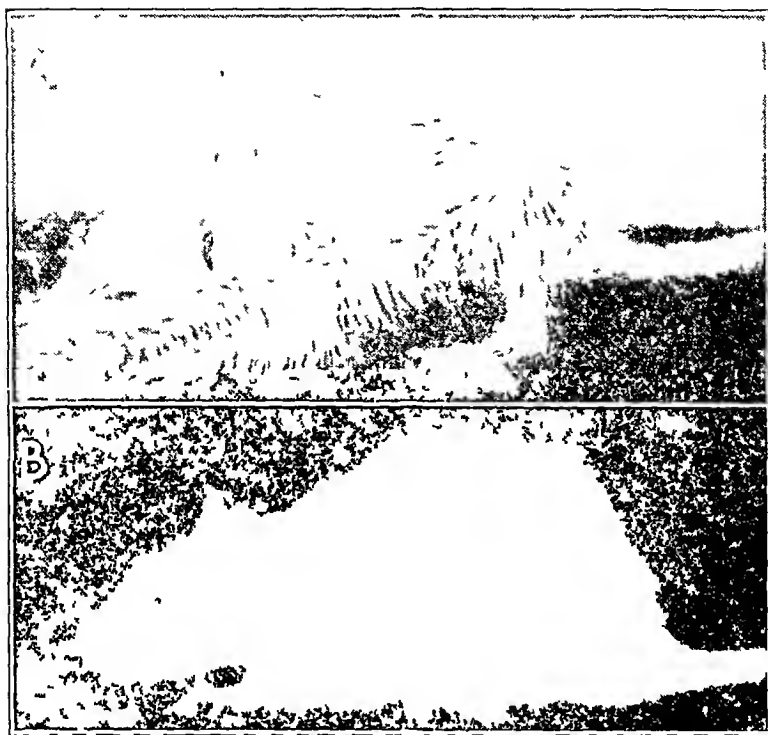


Fig 8—*A*, rat presenting the characteristic changes of general deficiency and spectacle eyes, *B*, the same animal five weeks after administration of synthetic tryptophan

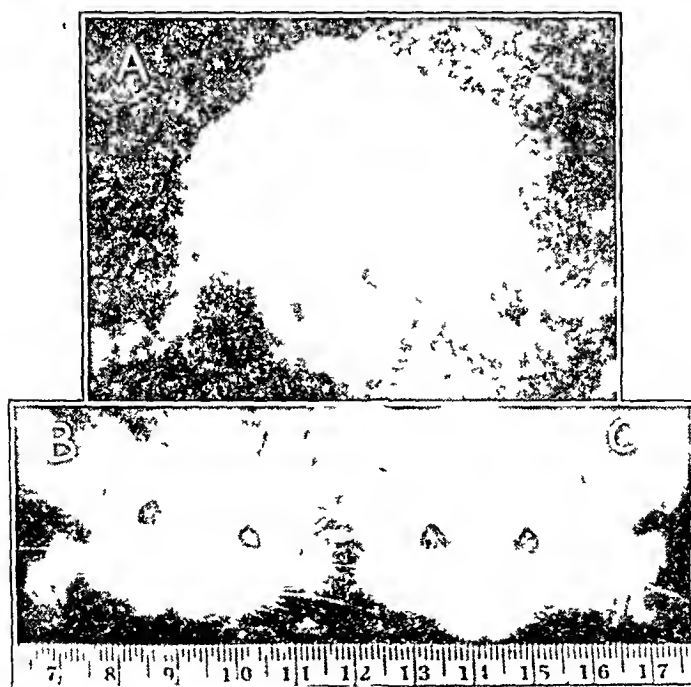


Fig 9—*A*, animal presenting the general and ocular signs of tryptophan deficiency, *B*, the same rat five weeks after administration of synthetic tryptophan, *C*, normal sibling, control animal

were allowed to develop for six to eight weeks, the addition of the tryptophan to the diet was without effect, and progression continued even when the dose of added tryptophan was increased to twice, two and in 1 case to four times, the amount used with the control animals. It is interesting to note that with the addition of tryptophan all other signs of tryptophan deficiency completely disappeared.

One animal was maintained on a tryptophan-deficient diet until it presented definite cataractous changes (controlled with ophthalmoscopic examination) for a period of four weeks, then tryptophan was added to the diet until the general condition and the ocular involvement definitely improved. At that time the animal was put back on a tryptophan-deficient diet until the signs of tryptophan deficiency reappeared. These were subsequently successfully treated except for the cataractous changes. Five times the rat was placed on a deficient diet, and five times recovery permitted the animal to see it through.

On one occasion the same animal was maintained on a tryptophan-deficient diet for three weeks, then, instead of tryptophan, another amino acid was added (*dl*-lysine) to the deficient diet. Even double amounts (proportionally calculated) of this amino acid did not result in beneficial effect, but soon after tryptophan was added to the diet improvement was striking except for the cataractous changes. This animal, after a year of experimentation, presented extreme cataractous changes of the lens, which finally remained stationary. At that time tryptophan was added in double amount, and the rat was maintained on this unchanged diet for another year. During this period the cataracts did not change visibly, and at the end of the second year the animal was killed. Histologic studies indicated the presence of pronounced cataractous changes.

#### COMMENT

Our experiments confirm, extend and complete some of the previous observations by Totter and Day,<sup>3</sup> Albanese and co-workers<sup>4b</sup> and Buschke<sup>5</sup> on rats maintained on tryptophan-deficient diets.

The ocular changes, in order of their appearance, may be described thus: 1. In younger animals (weighing 45 to 55 Gm) there appeared spectacle eyes, conjunctivitis, superficial vascularization of the cornea and occasionally cataractous changes in the lens. This group of animals did not resist for long on the deficient diet and generally died before presenting the more specific symptoms of tryptophan deficiency, noticeable to a greater degree in the next group. 2. In more developed rats (weighing 100 to 120 Gm) spectacle eyes were apparent at times, but less frequently and to a less pronounced degree than in younger group. However, corneal vascularization and, particularly, various degrees of cataractous changes in the lens were more constant. The latter type of alteration was more frequently noted in this group of rats than in

the first, or even the third. 3 In a third group, that of adult rats weighing 200 Gm at the beginning of the experiment, spectacle eyes and conjunctivitis were only occasionally noted, whereas vascularization of the cornea was more commonly observed.

We feel, therefore, that the cataractous changes in the lens developed more frequently (in our strain of rats) immediately before the rats reached the adult stage, when the young albino rats weighed approximately 100 to 120 Gm at the initiation of the experiment.

Whether or not any of the pathologic changes in the ocular structures just reported were caused primarily by the lack of tryptophan, or whether they were secondary to lesions elsewhere in the body, cannot be decided at present, since our histologic studies of all the other organs and endocrine glands are not yet completed. However, it is established that tryptophan is able to prevent, improve and cure the general clinical, as well as some of the ocular, symptoms produced experimentally by tryptophan-deficient diets. These changes are of two types: (a) the earlier ones, characterized chiefly by water splitting of the lens fibers and vacuolation, changes which our experiments have established to be reversible under tryptophan treatment, and (b) the more advanced ones, leading to disorganization of the structure of the lens, changes which seem to be irreversible.

We feel that the clinical manifestations cannot be secondary to partial inanition or starvation or to a vitamin deficiency because control animals in partial starvation and supplied with the same amount of hydrosoluble and liposoluble vitamins as those used with tryptophan-deficient animals did not present any of the aforementioned pathologic changes.

Further comparative clinicopathologic studies may enlighten us concerning the important question whether any of the experimental ocular alterations described have any relation to similar changes observed in pathologic conditions in man.

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# OCULAR CHANGES IN RATS ON DIETS DEFICIENT IN AMINO ACIDS

## II Corneal Dystrophy Due to Valine Deficiency

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OSBORNE and Mendel<sup>1</sup> were among the first investigators to demonstrate experimentally that some amino acids, although required only in a minimum amount, are essential to the life and development of animals. Their experiments were later confirmed by various authors, particularly Rose<sup>2</sup> and co-workers<sup>3</sup> who established more definitely that of the twenty-two most important amino acids ten are absolutely essential to growing animals and eight are necessary for the maintenance of the nitrogen equilibrium in adult man. However, not enough attention was paid to possible structural involvement of the various tissues and organs in the absence of the specific amino acids. In more recent papers,<sup>4,5</sup> Albanese and co-workers,<sup>4</sup> Buschke,<sup>5</sup>

Read at a meeting of the New York Society for Clinical Ophthalmology, March 4, 1946

From the Department of Neuropathology, New York State Psychiatric Institute and Hospital

1 Osborne, T B, and Mendel, L B. Amino Acids in Nutrition and Growth, *J Biol Chem* **17** 325, 1914

2 Rose, W C. The Significance of Amino Acids in Nutrition, in Harvey Lectures, 1934-1935, Baltimore, Williams & Wilkins Company, 1935, vol 49, p 65

3 Womack, M, and Rose, W C. The Relation of Leucine, Isoleucine and Norleucine to Growth, *J Biol Chem* **116** 381, 1936. McCoy, R H, and Rose, W C. The Relation of Glycine and Serine to Growth, *ibid* **117** 581, 1937. Gunther, K J, and Rose, W C. The Relation of Alanine to Growth, *ibid* **123** 39, 1937. Rose, W C, and Rice, E E. The Significance of the Amino Acids in Canine Nutrition, *Science* **90** 186, 1937

4 (a) Albanese, A A, Holt, L E, Jr, Kajdi, C N, and Frankston, J E. Observation on Tryptophane Deficiency Rats. Clinical and Morphological Changes in the Blood, *J Biol Chem* **148** 299, 1943. (b) Albanese, A A, Randall, R M, and Holt, L E, Jr. The Effect of Tryptophane Deficiency on Reproduction, *Science* **97** 312, 1943

(Footnotes continued on next page)

Maun and associates<sup>6</sup> and we<sup>7</sup> reported various structural changes associated with diets deficient in tryptophan,<sup>8</sup> lysine,<sup>4b</sup> phenylalanine,<sup>6a</sup> leucine<sup>6b</sup> and histidine<sup>6c</sup>

In the report on rats maintained on tryptophan-deficient diets,<sup>7</sup> two of us (A F and L R) discussed certain general structural changes, particularly of the ocular tissues, among which the most important were various cataractous changes of the lens and superficial vascularization of the cornea

In this preliminary communication, we wish to report observations on rats reared on a valine-deficient diet. A detailed report of the diets, general clinical observations and histologic changes in other organs and their relation to other dietary deficiencies will be given in a subsequent paper

#### EXPERIMENTAL PROCEDURE

In this investigation, 12 albino rats of the Sherman strain were used, 6 of them weighed 100 Gm each, the other 6, 200 Gm each. All the animals were of the male sex, were selected from the same litter and were of the same age and approximate weight

The diets consisted of a completely synthetic mixture of all the essential amino acids, as described by Rose and Epstein, except for the vitamin mixtures, which were freshly prepared<sup>7</sup>

There were three control groups of animals: (a) animals reared on the same synthetic amino acid-deficient diet, to which valine was added from the beginning of the experiment, (b) animals which were maintained on the same valine-deficient diet until definite structural changes appeared, at which stage valine was added to the diet for the purpose of studying the reversibility of the structural changes, (c) rats maintained on a normal diet (Rockland's rat pellets) supplemented with the same mixture of vitamins

All four groups of rats (the deficiency group and the three control groups) were fed *ad libitum* except that in the deficiency group some of the animals were fed artificially toward the end of the experimental stage in order to prolong their life as long as possible

The duration of the experiments was from two and a half to four and a half months

The changes in the cornea were observed with the aid of the biomicroscope. The animals were killed at various stages of the experimental investigations. Some eyes were fixed in a 5 per cent concentration of solution of formaldehyde

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5 Buschke, W. Classification of Experimental Cataracts in the Rat. Recent Observations on Cataract Associated with Tryptophane Deficiency and with Some Other Experimental Conditions, *Arch Ophth* **30** 735 (Dec) 1943, Dystrophic Cataracts and Their Relation to Other Metabolic Cataracts, *ibid* **30** 751 (Dec) 1943

6 Maun, M D, Cahill, W M, and Davis, R M. Morphologic Studies of Rats Deprived of Essential Amino Acids. (a) I Phenylalanine, *Arch Path* **39** 294 (May) 1945, (b) II Leucine, *ibid* **40** 173 (Sept) 1945, (c) III Histidine, *ibid* **41** 25 (Jan) 1946

7 Ferraro, A, and Roizin, L. Ocular Involvement in Rats on Diets Deficient in Amino Acids. I Tryptophan, *Arch Ophth*, this issue, p 331

8 Albanese and others<sup>4</sup> Buschke<sup>5</sup> Ferraro and Roizin<sup>7</sup>

U S P in isotonic solution of sodium chloride, the others were fixed directly in 80 per cent alcohol and embedded in pyroxylin. Hematoxylin and eosin and the Van Gieson and Masson trichrome stains were used for the histologic studies

#### CLINICAL OBSERVATIONS

Two weeks from the beginning of the experiments the group of animals on valine-deficient diets began to lose weight. The external appearance and the general condition of the body changed progressively. Briefly, these changes consisted in modification of the fur (changes of color and falling off), easy fatigability, pallor of the skin and visible mucosa, hunched posture and disappearance of the subcutaneous fat tissue, in walking the majority of animals disclosed instability and incoordination of movements and, at times, loss of equilibrium, resulting in

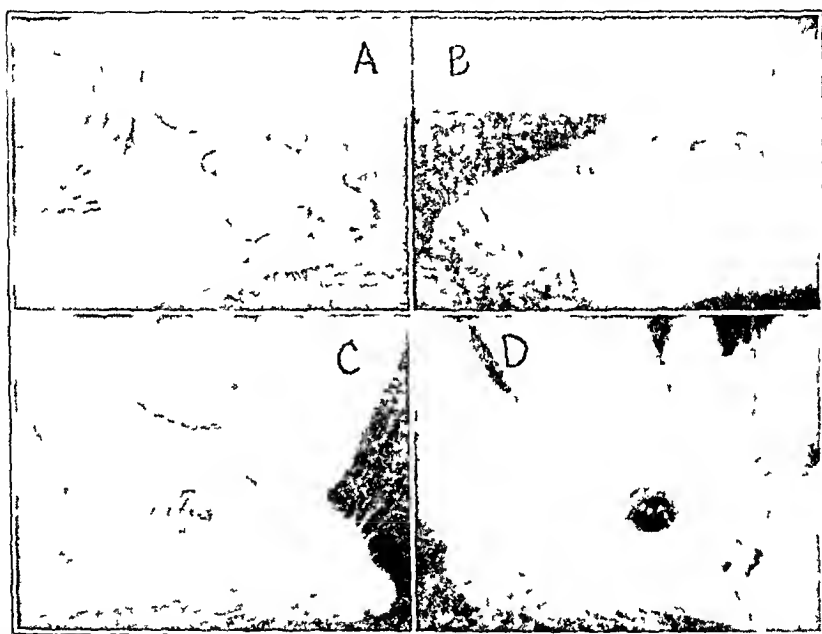


Fig 1—*A* and *B*, opacities of the cornea, *C* and *D*, normal appearance of the cornea in siblings of control rats

falling. They also often disclosed a tendency to rotate in a circular manner and to extend the head in an upward vertical direction.

Clinically, the first ocular changes were noticed four and a half to five weeks after the beginning of the experiments. They consisted in a progressive lack of luster of the cornea followed by loss of transparency, due to edema and, as the condition progressed, by dryness of the cornea, involving chiefly the interpalpebral area (fig 1).

In 1 case bullous keratitis developed in the interpalpebral portion, with edema of a mild degree involving the remaining cornea. The vascularization started as an arcade at the periphery and was consistently deep.

In advanced stages the corneal epithelium took on a dryness suggestive of xerosis, with desquamation of the superficial layers. The lens showed only slight changes, never sufficient to interfere with ophthalmoscopic studies. The changes were mostly water splitting and

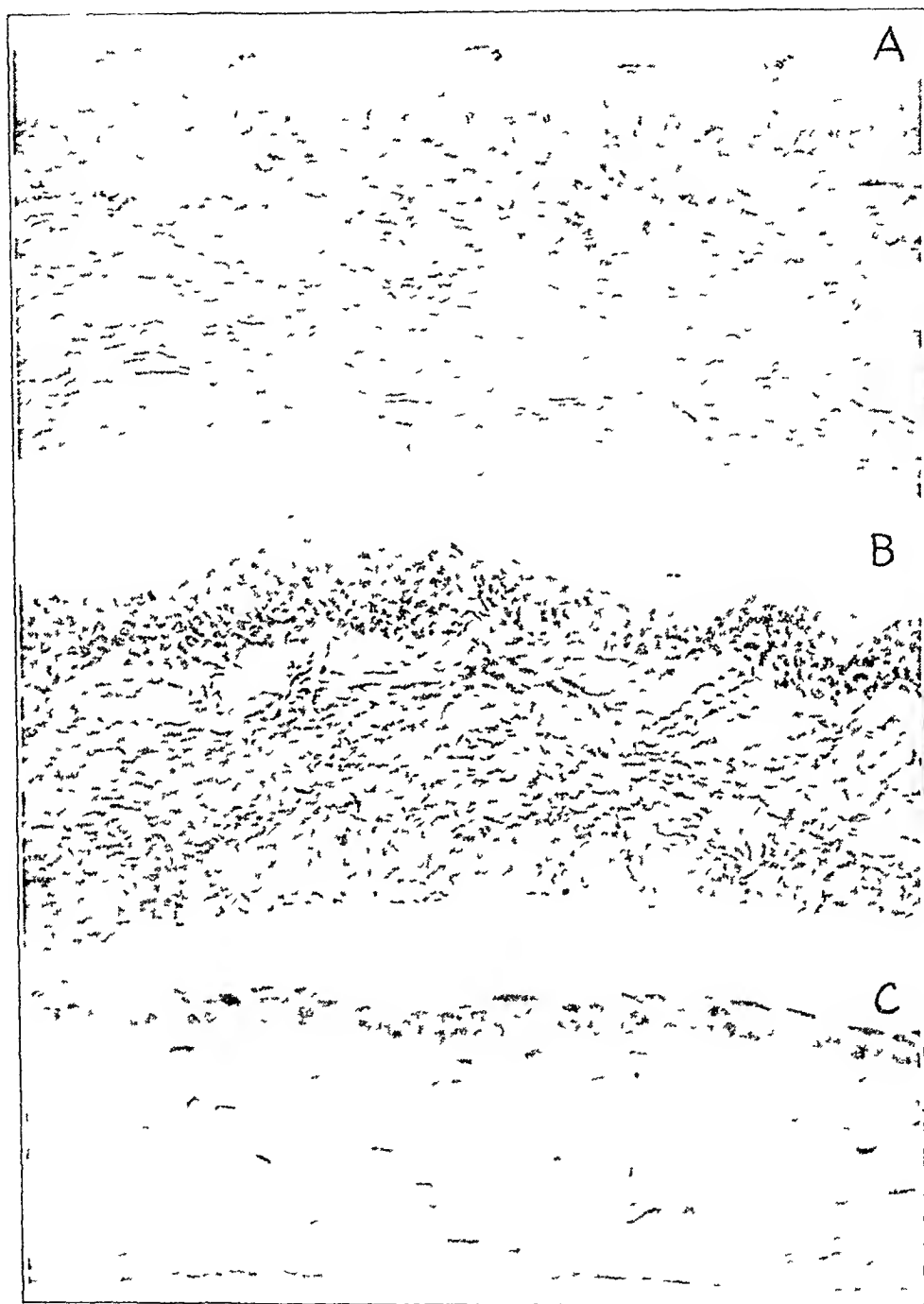


Fig 2—*A* and *B*, edema and early degenerative changes in the epithelial cells of the superficial layers of the cornea, *C*, normal histologic appearance of the cornea, of the control rat. *A* and *C*, hematoxylin-eosin stain, *B*, Van Gieson stain, low power magnification.

vacuolation in the anterior and the posterior cortex. The rest of the ophthalmologic studies showed a normal condition.



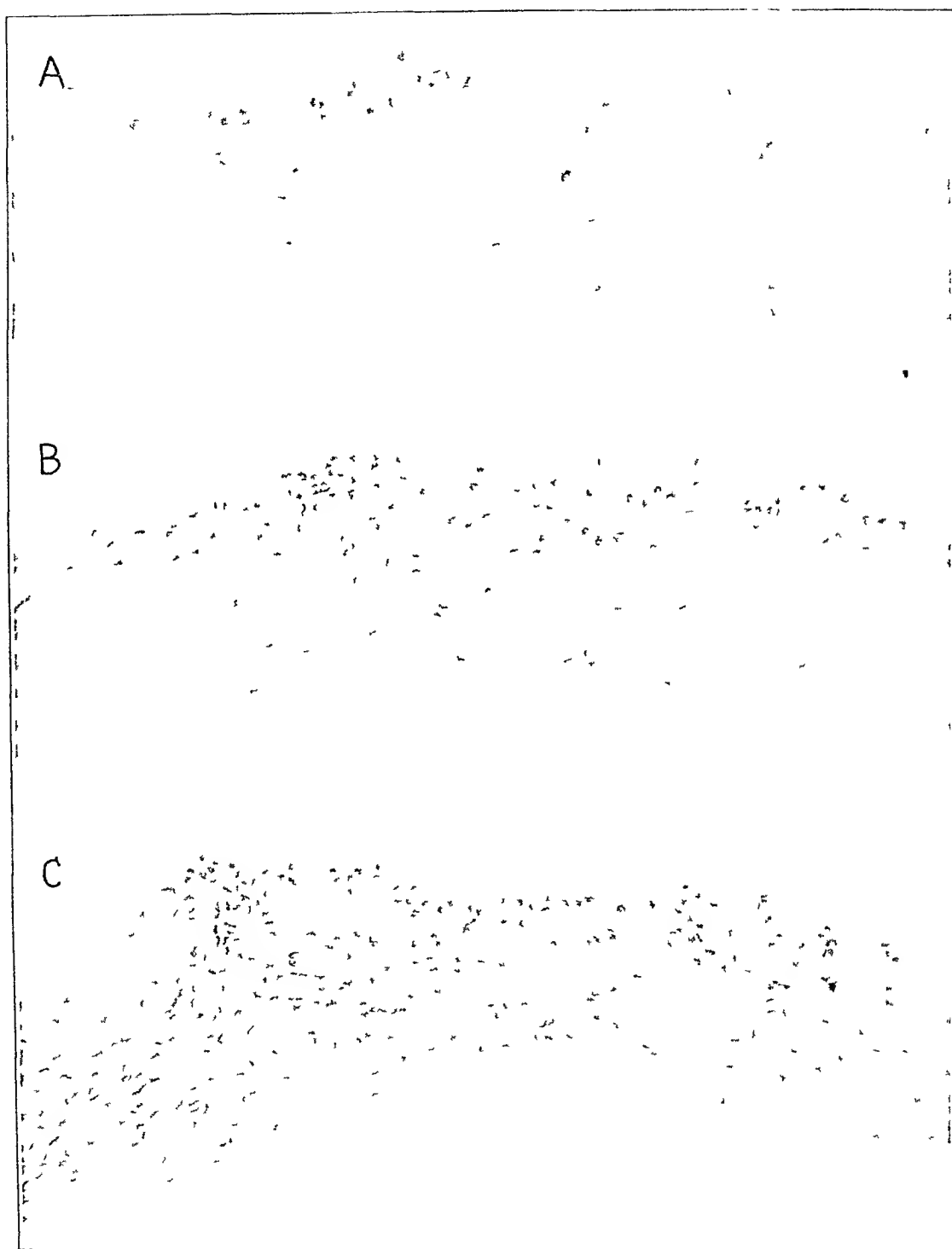


Fig 3—*A*, *B* and *C*, severer degeneration of the corneal epithelial cells of the cornea than that shown in figure 2, irregular stratification of the superficial layers, some keratinization and exfoliation. Hematoxylin-eosin stain, medium power magnification.

## MICROSCOPIC STUDIES

Histologically, in the early stages of valine deficiency, edema and degeneration of the epithelial cells of the superficial layers of the cornea was noticed (fig 2 *A* and *B*)

In more advanced stages the alterations were more pronounced, consisting of a more intense edema, severe degeneration of the various

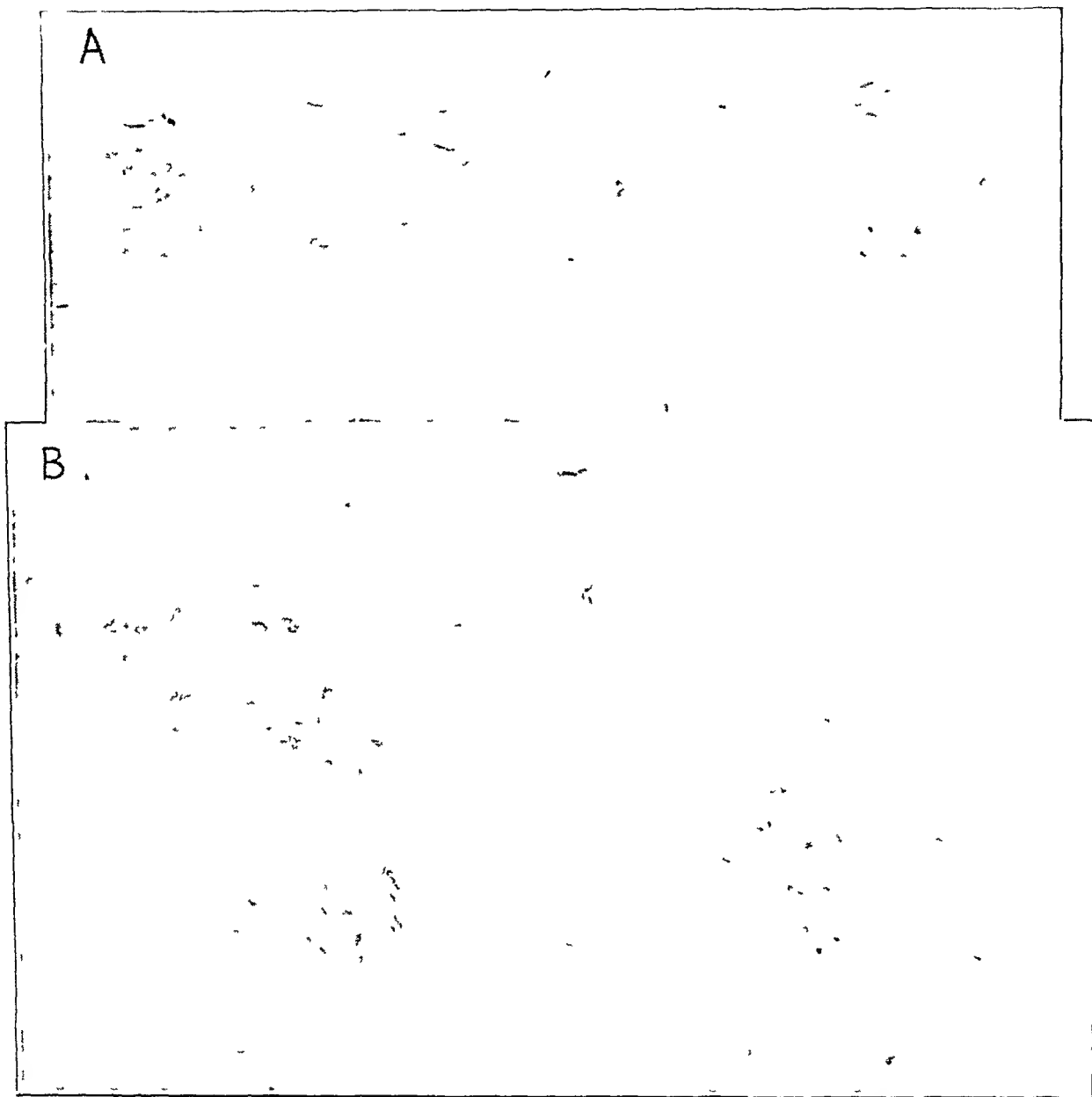


Fig 4—*A*, complete disorganization and keratinization of the cornea, hematoxylin-eosin stain, medium power magnification. *B*, higher magnification, illustrating severe changes. Hematoxylin-eosin stain.

epithelial cells, vacuolation of the protoplasm, displacement of the nucleus and, in certain areas, irregular stratification of the superficial layers, keratinization and exfoliation (fig 3 *A*, *B* and *C*). These struc-

tural changes, although apparent mostly in the superficial layers of the cornea, at times involved also the basal epithelial layer, which in certain areas appeared completely disorganized

In severer conditions all epithelial layers appeared almost completely disorganized and keratinized (fig 4 *A*) and the tissue appeared cornified, with almost no signs of cellular structures. In other instances only

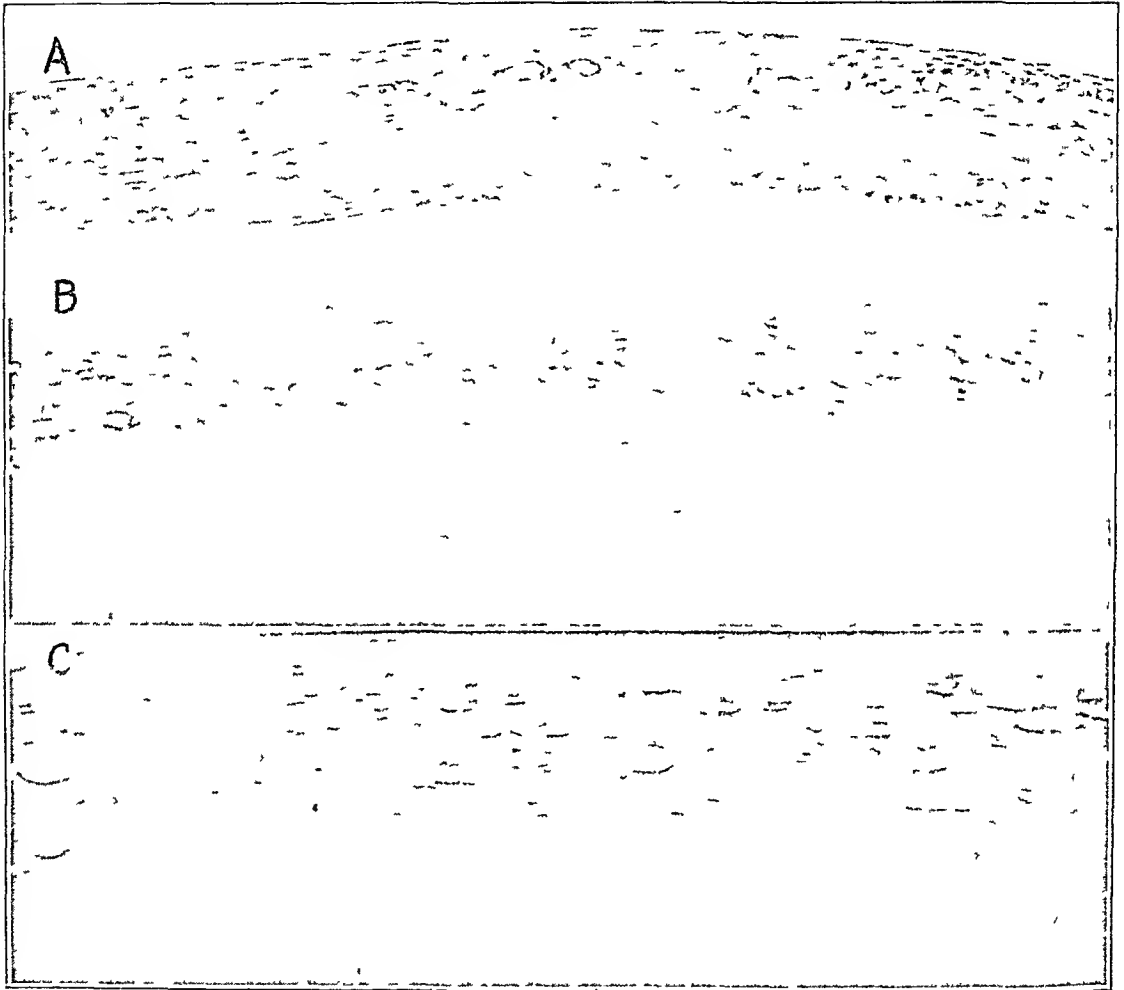


Fig 5—*A*, vascularization of the cornea, low power magnification *B* and *C*, vacuolation of the cortical region of the lens, medium power magnification *A* and *B*, hematoxylin-eosin stain, *C*, Van Gieson stain

shadow cells and some debris of disintegrated nuclei and cellular elements indicated the site of previous normal structures (fig 4 *B*)

In addition, intense congestion and occasional diapedesis of the morphologic elements of the blood were detected. Proliferation of the blood vessels was also conspicuous (fig 5 *A*). Occasional slight perivascular reaction of blood vessels of the surrounding stroma with mononuclear cells was encountered.

In 1 rat slight involvement of the lens was detected. It consisted mainly in vacuolation of the cortical region of the lens (fig 5 *B* and *C*). It never progressed beyond this stage, in contrast to animals on trypto-

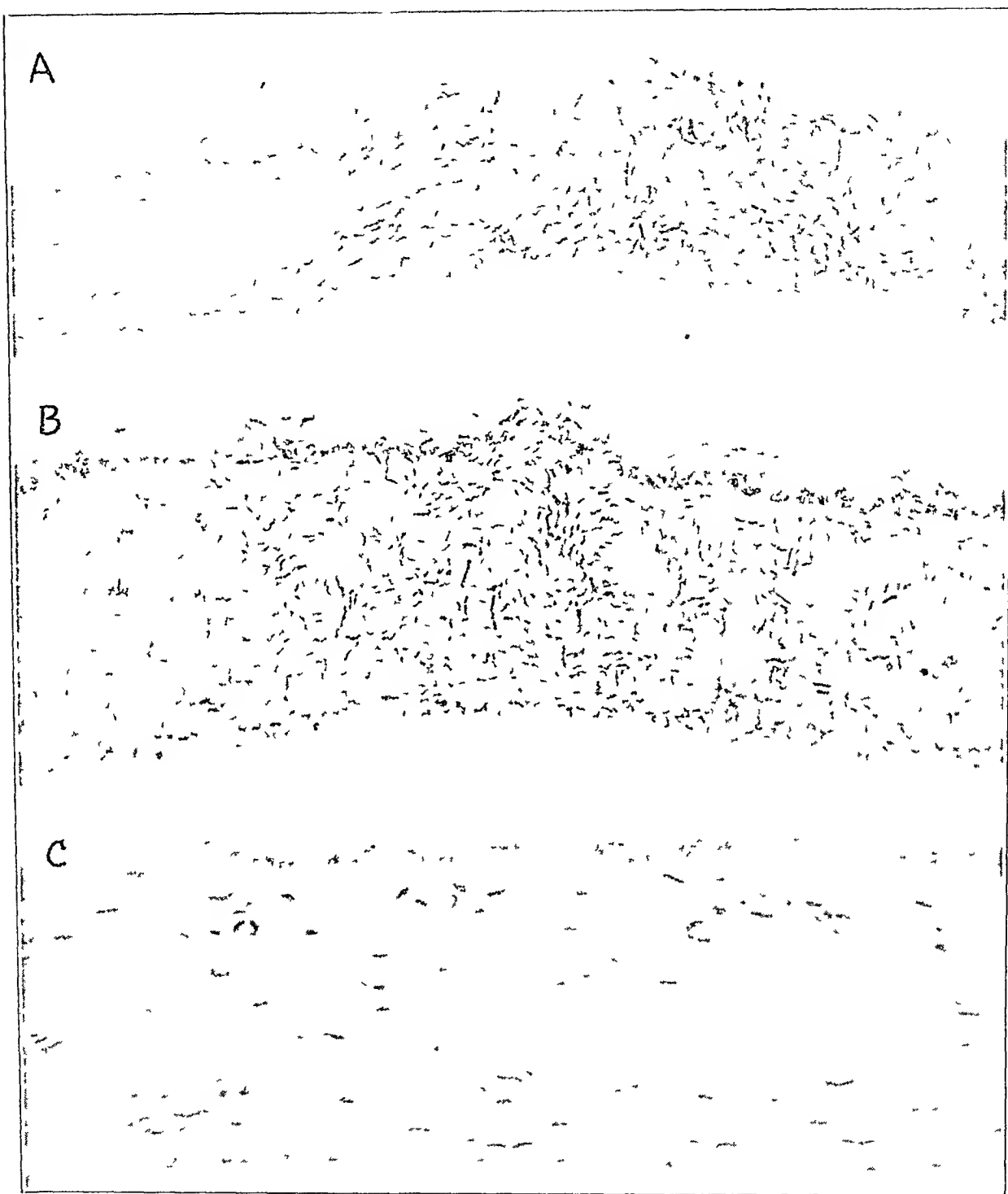


Fig 6—Less altered corneal structure, approaching a near-normal appearance, occasional presence of narrowed and mostly empty blood vessels (*C*). *A*, Masson trichrome stain, *B*, Van Gieson stain, *C*, hematoxylin-eosin stain. Medium power magnification.

phan-deficient diets, in which the process continued until complete cataractous changes of the lens had taken place<sup>7</sup>

Shortly after administration of the synthetic valine to the animals on the valine-deficient diet in which corneal changes were noticed clinically, the edema gradually disappeared and the cornea assumed its normal transparency. The blood vessels of the cornea narrowed and were finally empty of blood cells. At the same time, the general appearance and nutrition of the animals gradually improved. Of these animals, 1 was killed five weeks and the other seven weeks after administration of the synthetic valine. Histologically, the structure of the cornea was much less altered, approaching a near-normal appearance (fig 6A and B). Here and there dilated blood vessels were still visible, but empty (fig 6C).

#### COMMENT

Structural involvement of the ocular tissues in rats receiving amino acid-deficient diets was reported for the first time by Curtis, Hauge and Kravbill,<sup>9</sup> in 1932, and later (1941) by Totter and Day,<sup>10</sup> who recorded the occurrence of cataract in tryptophan-deficient rats. More recently Albanese and co-workers,<sup>11</sup> Buschke<sup>5</sup> and we<sup>7</sup> confirmed these observations while extending the investigation.

In 1939 Rose and Epstein<sup>11</sup> reported on the dietary indispensability of valine in rats. In their experiments these authors noted that the rats deprived of valine manifested peculiar symptoms, consisting particularly of extreme sensitiveness to touch, marked lack of coordination in movements, staggering gait and frequently "rotatory motion" in a clockwise or a counterclockwise direction. Whether this particular syndrome following valine deficiency is associated with specific lesions of the nervous system has not yet been determined.

In 1945 we repeated Rose's experiments (with minor modifications) with the purpose of investigating the possible structural involvement of various organs and tissues, particularly that of the central and peripheral nervous systems. In these experiments we were able to confirm Rose's<sup>11</sup> clinical observations. In addition, we noted the ocular alterations which are the subject of this discussion.

As already mentioned, the morphologic changes in the ocular structures in rats on valine-deficient diets consist mainly in a dystrophic change in the cornea as expressed by edema, various degrees of degeneration, chiefly of the superficial layers, hyperplasia of the epithelial

9 Curtis, P. B., Hauge, S. M., and Kravbill, H. R. The Nutritive Value of Certain Animal Protein Concentrates, *J. Nutrition* **5**: 502, 1932.

10 Totter, J. R., and Day, P. L. Cataract and Other Ocular Changes Resulting from Tryptophane Deficiency, *J. Biol. Chem.* **140**: 136, 1941.

11 Rose, W. C., and Epstein, S. H. The Dietary Indispensability of Valine. *J. Biol. Chem.* **127**: 677, 1939.

elements, and, in the more progressed stages, complete keratinization of the cornea. Although these histologic changes were frequently more pronounced in the superficial layers, they involved also the deeper tissues. In addition, there were pronounced deep vascularization of the cornea and slight vacuolation of the cortical region of the lens. The last two changes differ distinctly from those observed in the rats on a tryptophan-deficiency diet. (a) In the rats given the valine-deficient diet involvement of the lens never progressed beyond the stage of initial vacuolation of the cortex, whereas in the rats given the tryptophan-deficient diet the progression was usually gradual until a more or less complete cataractous change in the whole lens had taken place, (b) in the rats on the tryptophan-deficient diet the vascularization of the cornea was superficial, whereas in the rat on the valine-deficient diet it was of deeper distribution.

Whether or not the corneal dystrophy is caused primarily by the lack of valine or is secondary to other metabolic disorders related to lesions elsewhere in the body cannot be decided at present, owing to the incompleteness of our histologic studies of the other tissues and organs. However, it is certain that valine is able to prevent, produce improvement in and cure the ocular symptoms produced experimentally in rats with valine-deficient diets.

The ocular involvement cannot be secondary to inanition or other dietary factors of the synthetic diets used, because the control animals given the same synthetic diet with the addition of valine, and living under the same experimental conditions, did not disclose any ocular changes.

It is interesting to mention that during the preparation of this paper Maun, Cahill and Davis<sup>6b, c</sup> reported structural alterations in various tissues and organs in rats maintained for twenty-eight days on diets deficient in leucine and histidine. The ocular involvement consisted in "thinning and stratification" of the corneal epithelium with keratinization of the surface. The substantia propria appeared thickened, but the structural pattern was well preserved. The vessels immediately beneath the corneal epithelium were dilated and prominent, and in a few instances scattered leukocytes were present in the perivascular tissue. The structure of the rest of the eye was normal.

That ocular changes associated with a valine-deficient diet did not attract the attention of other investigators may be due to the fact that our animals were maintained alive for a longer period, owing to forced nutrition at the stage when the animals were disinclined to eat spontaneously. A longer duration of the deficiency may have brought about advanced, and thus more noticeable, ocular changes.

## CONCLUSION

✓ In rats maintained on a valine-deficient diet changes develop in the cornea, in addition to general changes and structural alterations in other organs, which are still the subject of microscopic studies. The corneal changes seem to be the result of edema and progressive degeneration, leading gradually to keratinization and disorganization of the epithelial structure of the cornea. These changes are generally encountered in the interpalpebral space. In addition, pronounced deep vascularization of the cornea is observed. Slight changes in the lens, characterized chiefly by vacuolation of the cortex, are only occasionally noted.

These structural changes in the eye appear to be reversible (if treated in time), as demonstrated by notable improvement following the administration of synthetic valine to the animals on a valine-deficient diet.

The corneal changes appear as the most prominent feature of the ocular involvement. At the present stage of investigation we feel justified in naming the corneal change "nutritional corneal dystrophy."

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## CATARACT COMPLICATING GLAUCOMA

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NEW YORK

**C**LINICALLY, cataractous lenses are encountered almost regularly in eyes with absolute glaucoma, especially those that are already aged. The symptoms of glaucoma and of cataract may merge into one another. Cataract in a glaucomatous eye progresses, no matter whether the tension has been kept down by a miotic or by operation.

The present paper, on cataract complicating glaucoma, is the sixth, and last, of a survey undertaken to record all microscopic changes that can possibly take place in the lens as a result of lesions in other structures of the globe. The papers already published dealt with cataracts associated with ulcers of the cornea,<sup>1</sup> scars of the cornea,<sup>2</sup> iridocyclitis,<sup>3</sup> detachment of the retina<sup>4</sup> and malignant tumors.<sup>5</sup> In these five papers, 154 cases of complicated cataract were studied and, as occasion arose, the influence of glaucoma as a secondary factor in the production of the cataracts was discussed. To this extensive and varied material are now added 31 cases of cataract that was believed to have been caused by glaucoma. This makes a total of 185 cases, illustrated with 61 drawings. Twenty of the 31 cases of the present paper represent primary glaucoma, mostly in the absolute stage. The remaining 11 cases represent secondary glaucoma. The effects of increased tension on parts of the eye other than the lens will be considered first.

### THE RETINA

It was a striking fact that the retina in no less than one-half the cases of primary glaucoma showed a large amount of hemorrhage, often

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Read at the Eighty-Second Annual Meeting of the American Ophthalmological Society, San Francisco, July 26, 1946

1 Samuels, B. Lesions in the Lens Caused by Purulent Corneal Ulcers, *Tr Am Ophth Soc* **39** 66-72, 1941

2 Samuels, B. Cataract Complicating Corneal Scars After Perforating Ulcers, *Tr Am Ophth Soc* **40** 292-304, 1942

3 Samuels, B. Pathology of the Lens in Non-Traumatic Iritis, *Tr Am Ophth Soc* **41** 262-272, 1943

4 Samuels, B. Complicated Cataract Associated with Spontaneous Detachment of the Retina, *Tr Am Ophth Soc* **42** 109-117, 1944

5 Samuels, B. Cataract Associated with Intraocular Tumors, *Arch Ophth* **35** 366-383 (April) 1946



extending beyond the equator. It was evident that the interference with the venous circulation and the glaucoma were closely connected. In no instance could it be decided whether glaucoma had led to an obstruction in the venous outflow or whether an impediment in the latter had led to glaucoma. It is known that in cases of advanced glaucoma the sclerosed retinal artery may press on the retinal vein in the hiatus on the posterior surface of the lamina cribrosa. The different stages of interference with the retinal circulation determine the appearance of the fundus. Varicosities and newly formed blood vessels near the papilla indicate that there is incomplete interference with the venous outflow. These are signs that warn against operative intervention, because hemorrhage may take place from the thin-walled vessels and also because abnormal blood vessels in any part indicate a generally poor state of the whole globe. Massive hemorrhages following complete occlusion of the central vein are familiar to all. In 1 case of secondary glaucoma in this series, diagnosed in life as thrombosis of the central vein, the effects of occlusion of the vein on the general circulation, and indirectly on the lens were clearly shown. The patient was 74 years old. The retina was hemorrhagic and atrophic. The shallow anterior chamber was filled with blood, and a hematogenous membrane covered the iris. The cataract was believed to have been hastened to maturity by toxins from decomposing red blood cells in the anterior zone. A rare clinical picture in absolute glaucoma is that in which no blood vessels, or only a few attenuated ones, are visible, owing to endarteritis obliterans in the main retinal artery.

#### THE IRIS

The state of a glaucomatous globe may be ascertained by a study of the anterior part of the uvea. As examples of hopeless conditions the specimens showed necrosis of the iris, pathologic ectropion of the uvea and shrinkage of the whole iris. In 8 cases blood vessels on the anterior surface of the iris, which are merely endothelial tubes that rupture easily, even from a paracentesis, spoke against operative procedures.

#### THE CILIARY BODY

In practically all cases atrophy of the ciliary body was noted, and always without membrane on the surface which would have impeded the secretion of the aqueous. Atrophy of the ciliary body is commonly attributed to insufficient blood supply and altered metabolism. Necrosis of the ciliary processes, so frequently recorded in the paper on cataract associated with intraocular tumors, was rarely seen, proving that in cases of absolute glaucoma from necrotic tumor the necrosis is the effect of toxins.

## CONDITION OF THE VARIOUS STRUCTURES OF THE LENS

*The Capsule*—In a majority of the cases the capsule showed no folds. In 1 case deep folds were present, the result of contraction on the part of an anterior capsular cataract and a pupillary membrane. The fact that there was deep keratitis made it likely that the development of cataract had been hastened by uveitis following an operation. In short, absence of folds in the capsule was considered to be typical and characteristic of the lens in cases of glaucoma.

Strictly speaking, 1 of the cases of absolute glaucoma (fig 6) did not belong to the present survey, but because it showed the danger of touching the tense capsule in a glaucomatous eye it was included. Six weeks prior to enucleation the lens had been punctured by the needle of a syringe in an attempt to withdraw aqueous. The capsule

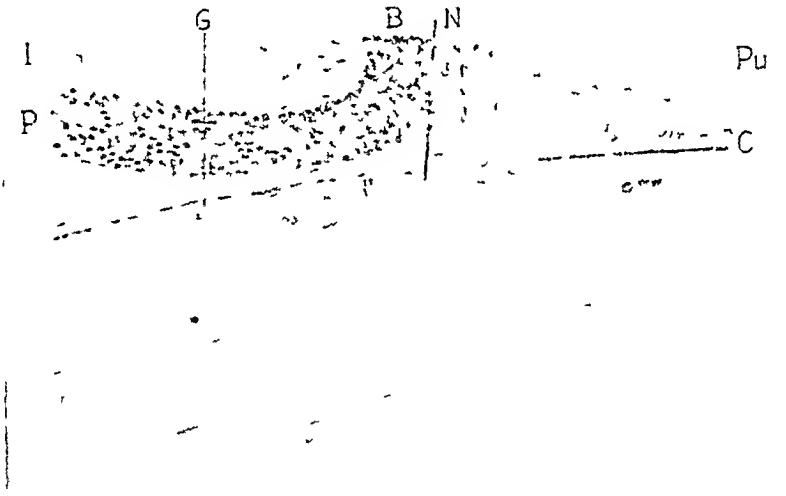


Fig 1—Hemorrhagic glaucoma in the eye of a man aged 54. Most of the lens, including the germinal zone, was in order. At *PU* the pupillary area is filled out by blood and fine pigment particles. The iris (*I*) is entirely necrotic, and the pigment epithelium (*P*) is broken down. At the pupillary border (*B*) a mass of nuclei (*N*) from desquamated cells appears under the capsule (*C*) in the liquefied cortex. To the left there are two buds of cells suggesting giant cells (*G*), which are due to localized proliferation of the capsular epithelium. Between (*G*) and (*N*) the epithelium is irregular and only acquires a normal appearance to the left of the picture. In the deeper zone there are two cavities, containing a brownish substance.

was absent over the entire anterior surface of the lens, having been stroked back by a mass of escaping and expanding lens matter. In nonglaucomatous globes a small rent in the capsule causes it to retract a little and to be thrown into folds, but, here, from the tiniest pick an enormous opening in the capsule developed to make way for the escape of expanding lens substance. Postoperative spontaneous rupture of the distended capsule is known to occur in cases of glaucoma when the lens is tilted and presents itself in the wound.

*The Epithelium*—Concurrent with the smooth, and even overlying, capsule, the epithelium was as a rule well preserved, accounting for the rarity of an anterior polar cataract associated with glaucoma. In 1 instance (fig 1) glaucoma had caused necrosis of the pupillary zone of the iris and this, in turn, necrosis of the underlying subcapsular epithelium. The epithelium adjoining the necrotic area proliferated in an effort to repair the damage. Prevented from doing this, it grew back on itself, forming a tuft of cells. Apparently, the subcapsular epithelium has the property of repairing defects similar to that of the endothelium of the cornea. It is not uncommon to see at the margin of a defect in the endothelium on Descemet's membrane a clump of cells which may be so large as to be visible with the naked eye. Such a formation may break off and float in the aqueous, or it may attach itself

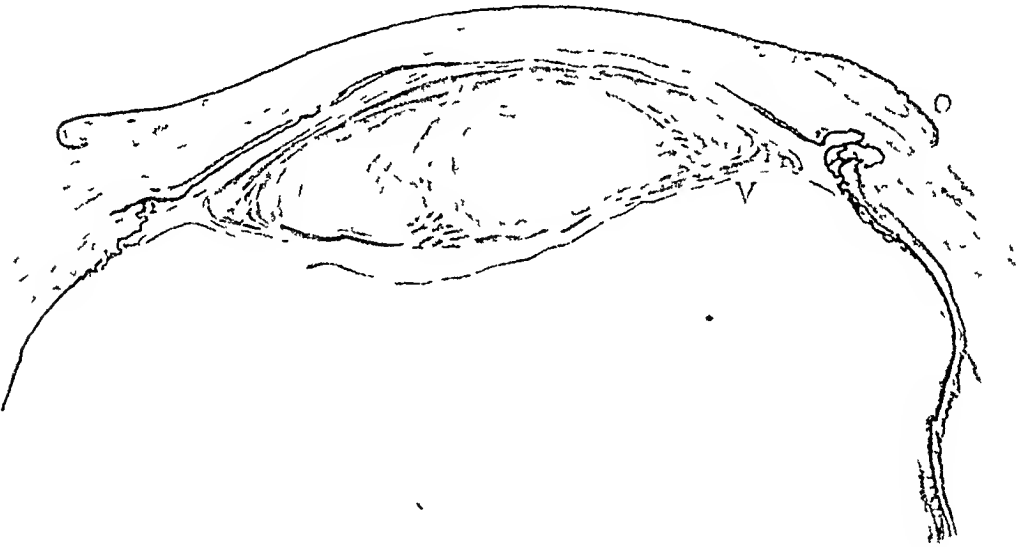


Fig 2—The eye of a man aged 47. An iridectomy for glaucoma had been performed three months before enucleation. The wound gapes and is outlined by a layer of pigment. The overlying conjunctiva is swollen and cystic (*O*). On both sides the thin and compressed iris lies against the cornea. The anterior chamber is abolished, the slitlike opening being an artifact. The vitreous (*V*) has pressed the lens forward, causing the posterior surface to be less convex than the anterior—the reverse of normal. The ciliary body is atrophic and compressed. A ciliary process is drawn into the wound.

to the iris and form an island of endothelial cells. In a similar way, the subcapsular epithelium may proliferate at the margin of a defect and form a nodule, which may cling to the capsule or float in the liquefied cortex.

*The Germinal Zone*—The germinal zone, like the subcapsular epithelium, was not as a rule greatly damaged. Several times it was

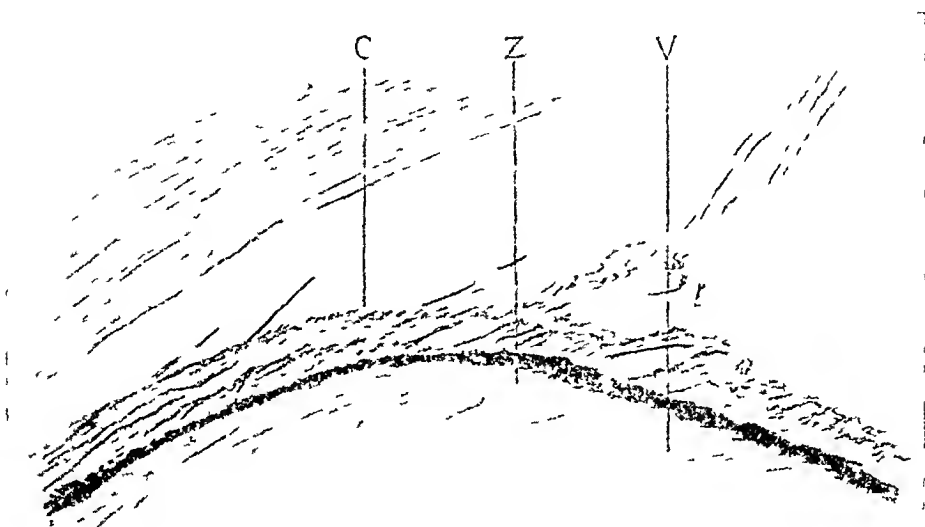


Fig 3—Detail of figure 2 taken from the flat part of the ciliary body (C) Sharp folds of the anterior limiting layer of the vitreous (V) project into the spaces between the zonular fibers (Z)

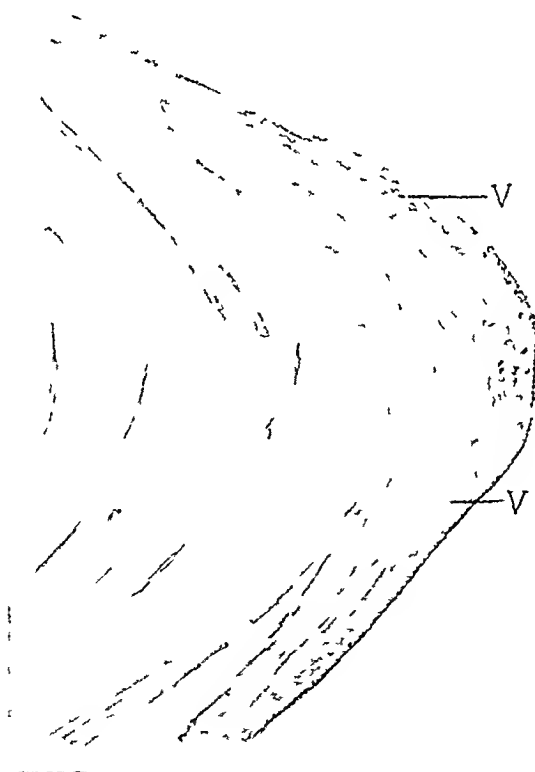


Fig 4—The eye of a man aged 66 Absolute glaucoma had led to shrinkage of the iris and formation of a membrane on it In the drawing, the lenticular changes are minute and are restricted to the equator They consist of a row of small vacuoles (V), which bisect the germinal zone, leaving intact lens fibers, with their nuclei on either side

absent on one side but preserved on the other, just as the ciliary body may be atrophic in one sector and normal in the others

*Vesicular Cells*—Vesicular cells, when present, were noted only in small amounts. The scarcity of these cells was explained by the fact that in this glaucomatous group the cataracts were never as far advanced as in the cases of iridocyclitis and detachment of the retina, in which vesicular cells were numerous and characteristic

*The Lens Substance*—Disintegration and liquefaction of the lens substance, so frequently noted in the cataracts described in the previous papers, were seldom observed and therefore were not considered characteristic of glaucomatous cataract. In fact, in most instances the damage to the lens substance was relatively insignificant. Shrinkage of lens and folds in the capsule were rare and could always be explained by a condition other than increased tension. A shrunken lens would be

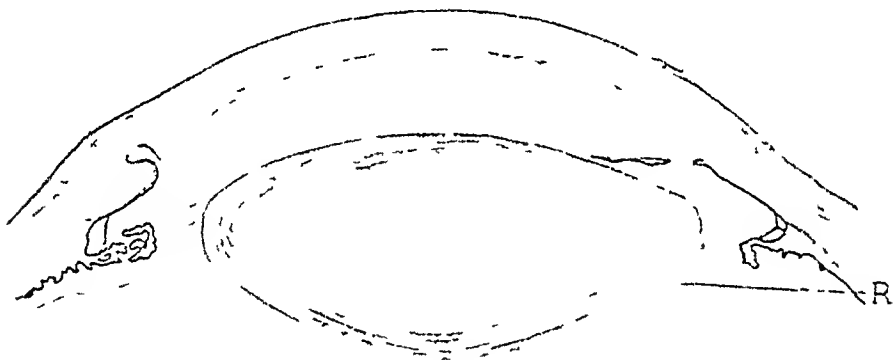


Fig 5—To the left are shown traces of the scar from an operation, partially permeated with blood. The cavity is lined with iris pigment. A thin, pigmented layer, all that remains of the iris, lines the internal sulcus of the sclera. A few red blood cells lie against the flat part of the ciliary body, and a few are seen in the recessus hyaloideocapsularis (R), which opens in the normal direction laterally. Practically no change can be recognized in the lens in spite of a clinical history of opacity and discoloration.

antagonistic to increase of tension, and a totally disintegrated lens would seemingly lead to shrinkage.

*Vacuolation of Lens Fibers*—A system of vacuoles was a frequent observation in the subcapsular substance of the lens in these glaucomatous eyes, originating in a disintegration of the lamellas (fig 4). The starting point of a system was near the pupillary margin of the iris, extending from here equatorially to the point where the capsular epithelium turns inward to form the germinal whorl. At the start the vacuoles were small, but before they disappeared they became larger and more conspicuous. When the system of vacuoles was narrow it usually split

the germinal zone into two parts, an inner and an outer, but when it was broad it entirely replaced the inner layers of the germinal zone, leaving a narrow strip of nuclei to the outside. These vacuoles were generally more superficial than those seen in senile cataract.

*Fragmentation of Lens Fibers*—Bearing a special relation to the system of vacuoles, but different from them, was a peculiar form of fragmentation of the fibers, seen in the subcortical layer, to the inner side of the germinal cells, in 2 cases (figs 8 and 10). This layer has normally a homogeneous appearance, but in these 2 instances the fibers were fragmented into small oblong units, sharply separated from one another. A fiber was never involved in its entire length. In a histologic sense, the fragmentation was similar to that seen in degenerating nerve fiber sheaths of the optic nerve with the Weigert method of staining. This similarity led to the conclusion that this picture was not an artefact but

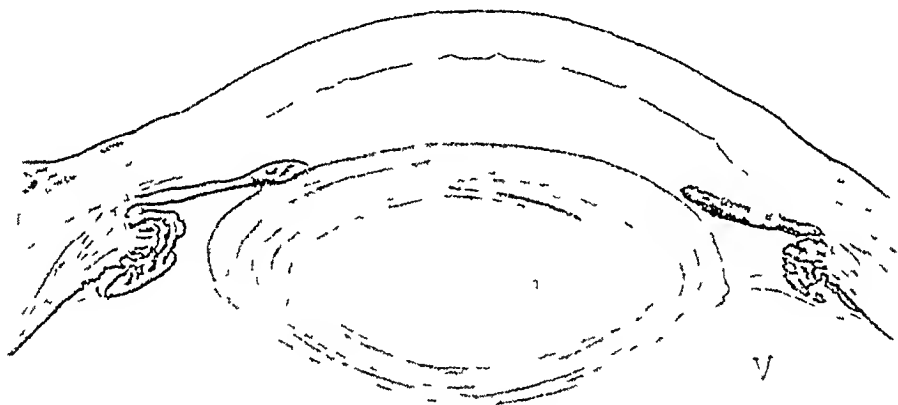


Fig 6—The eye of a man aged 42 was enucleated because of absolute glaucoma. The anterior chamber is shallow, and the filtration angle is obliterated. The iris is partially necrotic and contains numerous pigmented cells which have migrated into it. To the left the swollen pupillary margin of the iris is adherent to the lens and the underlying pigment layer is dissolved. The ciliary body is somewhat swollen, and the processes touch the root of the iris on both sides and press it against the cornea. The vitreous (V) is homogeneous. Its anterior limiting layer bulges forward into the circumferential space much farther than normal, especially on the left side, where it touches the ciliary processes over a broad area.

represented a stage in the formation of senile cataract. In all probability, increase in tension had little to do with it, otherwise, it would have been encountered before in the many lenses examined.

*Discrepancy Between Clinical and Pathologic Changes*—One case of primary glaucoma was especially important in that clinically so much was seen, yet histologically so little. A yellowish white cataract was visible through a wide coloboma in the iris. Microscopic study showed only a scattering of cells in the posterior cortical layers (fig 5), which

certainly could not have given the appearance of a "yellowish white cataract." Probably imbibition of fluid caused a change in the refractive index of the lens fibers without actually altering them. Unfortunately, such edema cannot be demonstrated in stained preparations. In life, edema in the cornea may occur after injury, causing it to take on a whitish hue, which disappears in time—proof that no essential damage was done to the lamellae. Similarly, the lens in diabetes may become whitish and swollen and with insulin treatment return to normal.

Occasionally a patient with a mature cataract is able to count fingers at several feet. Better known is the fact that in a case of glaucoma

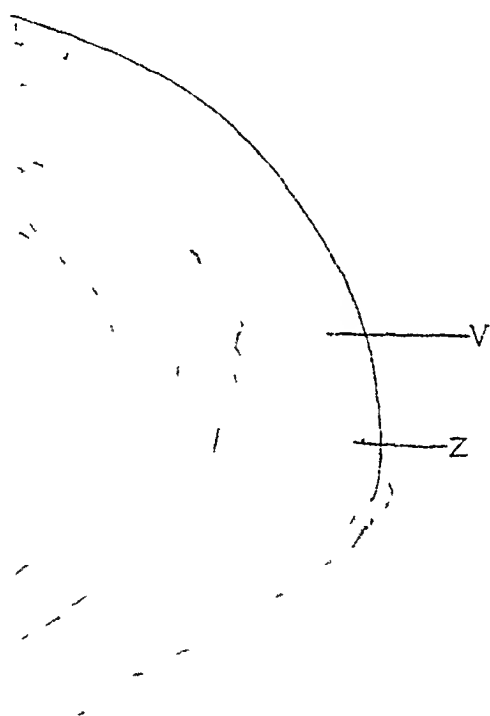


Fig 7—Detail of figure 2. At one place the capsule is separated from the germinal zone by an artefact, due to traction by the zonular fibers. The germinal zone (Z) is but little changed. Bordering its inner surface a row of small vacuoles (V) extends forward, gradually approaching the surface until it becomes subcapsular. The vacuolation is different from the fragmentation shown in figure 8.

with a totally excavated nerve head the patient may have good central vision, although the field is restricted. Interesting from this standpoint was the case of a woman aged 48 with absolute glaucoma of twelve months' duration. In spite of an almost total cataract and a deeply excavated nerve head, filled out with organized blood clot, the patient could discern hand movements at 2 feet (30 cm).

*Size of the Lens*—Although most of the lenses were in a swollen state, they were seldom much enlarged. However, the measurements of a lens in a slide are uncertain, first, because the fixation may cause it to shrink or swell according to the fixation used, and, second, because one is seldom sure that the section has been taken from the true meridian, and not from the slanting surface.

*The Circumlental Space*—The measurements of the circumlental space, like those of the lens, were unsatisfactory because the width of the space is influenced by the way the section is cut and by the fixation fluid used. For instance, an eccentric cut through the lens produces an

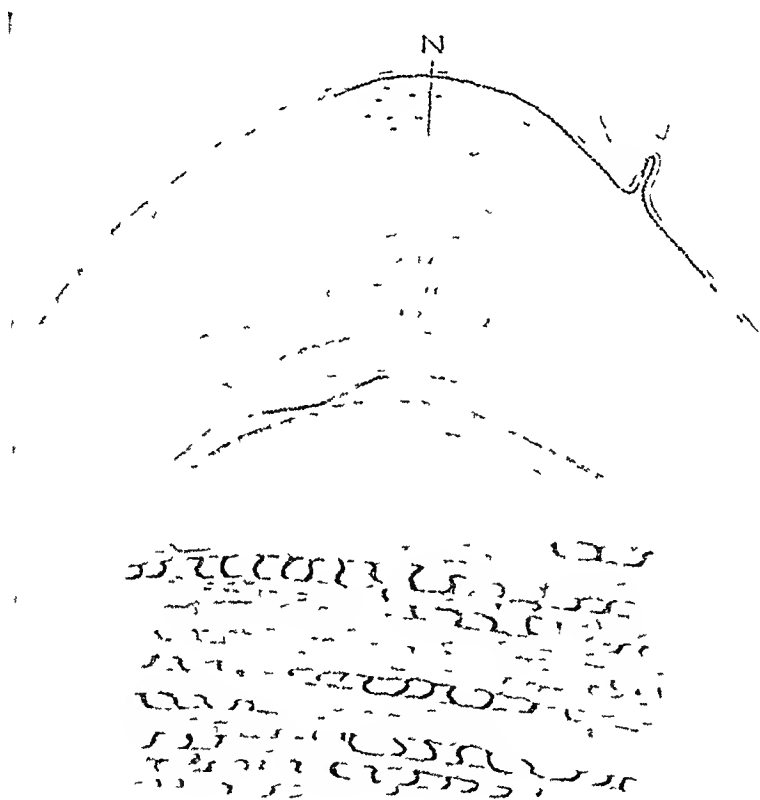


Fig 8—The eye of a man aged 76 which had had absolute glaucoma for four years and six months before enucleation. The germinal zone (Z) is normal. To its inner side, in the subcortical region, files of fragmented zonular fibers are seen. They are not in the form of droplets, but are cylindric bodies, separated from one another by irregular oblique lines.

oblique section through the circumlental space and causes the latter to appear broader. Slight artificial detachment, due to shrinkage, may cause the processes to approach the lens. There was only 1 case in which the ciliary processes came into actual contact with the equator of the lens, and in this case they were extremely swollen.

*Position of the Lens*—There was 1 example of the effect of a swollen and hardened vitreous on the lens after the glaucomatous globe had been opened (figs 2 and 3). The patient was 47 years old. Three months



before the enucleation an iridectomy was performed to relieve the tension. The wound was ectatic, and the lens was pressed forward, completely occupying the corneal cavity and molded to its contour. The ciliary body was compressed by the vitreous, which bulged far forward into the circumferential space. As a complication following a filtering operation, this eye was thrown into a condition known as malignant glaucoma. By this term some surgeons designate cases in which, after an operation, a glaucomatous eye (glaucoma simplex) which has never shown inflammatory symptoms becomes harder than it was before and is inflamed. It makes little difference whether the operation is an iridectomy, a Lagrange operation (sclerectomy with scissors) or an Elliot sclerectomy with trephining. The anterior chamber remains abolished, and the wound may gape. There is severe pain, which is worse at night. The most disagreeable feature is that it is impossible to restore the anterior chamber or to lower the tension or relieve the inflammation. One can-

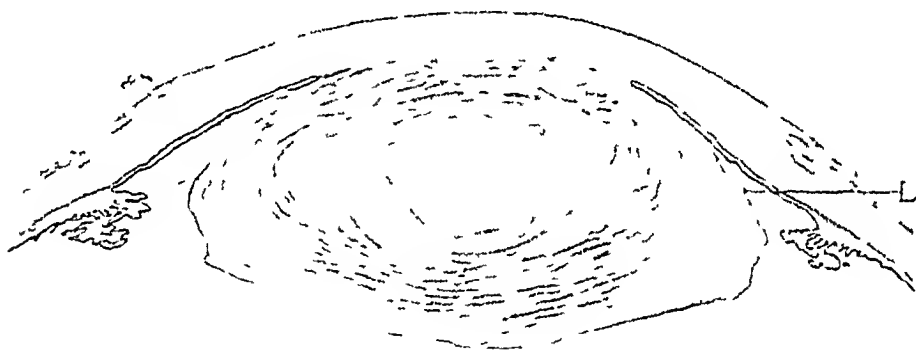


Fig 9—An eye with absolute glaucoma. The lens is disorganized and pressed against the cornea, which is bare of endothelium. The capsule of the lens (L) ends a short distance in front of the equator. Anteriorly there is not a trace of the capsule. The ciliary body on both sides is atrophic.

not foretell the tendency of glaucoma simplex to develop into postoperative glaucoma malignum. If this happens to one eye, an operation on the other eye is likely to be followed by the same complication, indicating that there is a constitutional inclination.

It is generally thought that malignant glaucoma, particularly since the lens is sometimes tilted into the wound, is always caused by a subchoroidal hemorrhage. In this series there were 2 cases of postoperative malignant glaucoma which were evidently caused by nonexpulsive subchoroidal hemorrhage. On the other hand, there were 2 cases in which the choroid was not detached. Here the cause of the malignant postoperative attack was certainly pressure from a swollen and hardened vitreous body. A theory as to the cause of primary glaucoma is that

first the pupil dilates and then the ciliary body becomes hyperemic from disturbance in circulation. This theory fails to explain the anatomic observations in the cases included in this paper, in which the ciliary processes were compressed against themselves or were pushed far forward. Hyperemia alone could not have displaced these processes. This was certainly the mechanical result of an expanded and hardened vitreous.

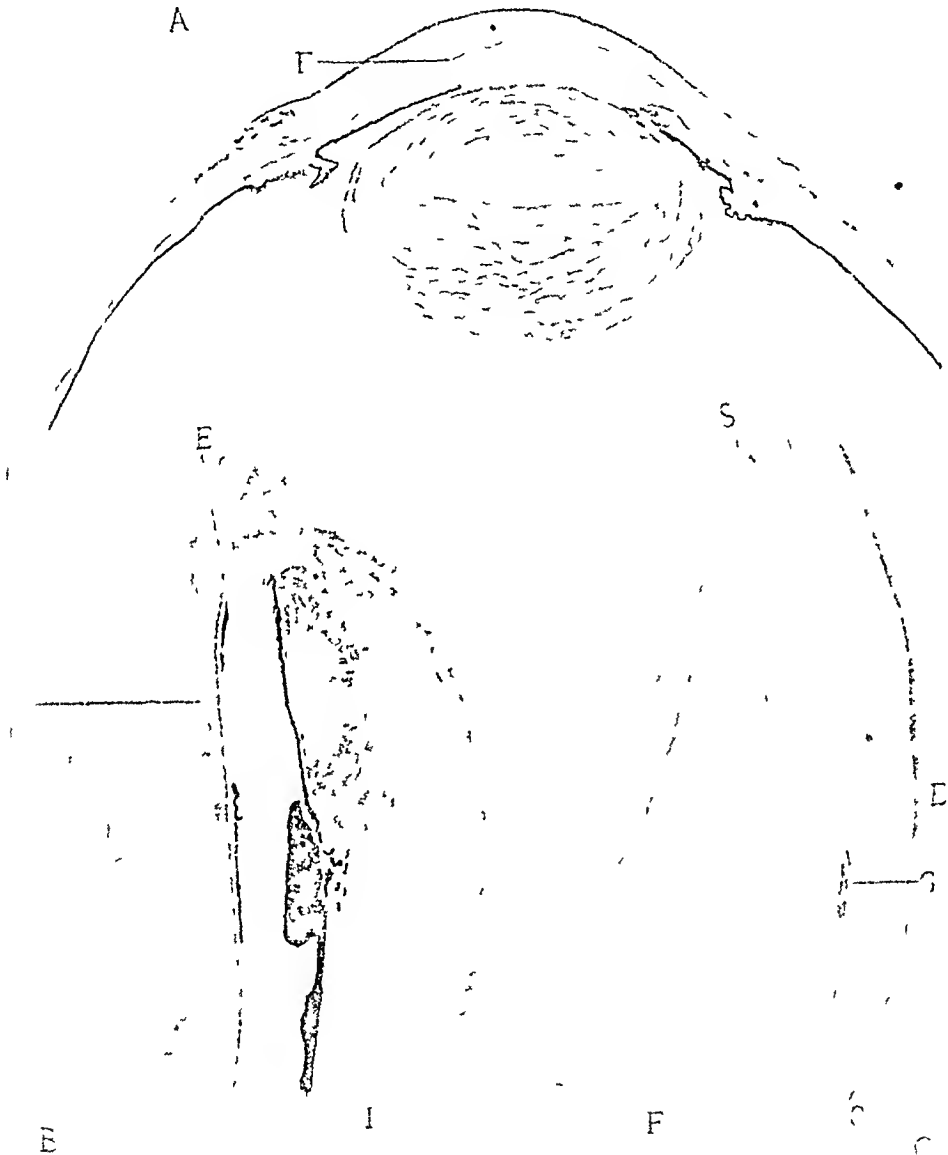


Fig 10—An eye with absolute glaucoma

(A) The fine filament detached from the cornea represents a coating of red blood corpuscles. The iris is necrotic (B). The lens is broken up and swollen.

(B) The iris (I) is shadowlike, containing but a few nuclei. A row of red blood cells outlines the anterior limiting layer. The sphincter muscle is gone, and in its place are a few empty endothelial tubes. The desquamated pigment layer is gathered into a large black mass. The capsular epithelium (E) is normal. Beneath it, at (N), loose nuclei derived from desquamated cells lie in decayed lens matter. In the lens substance are many slits, debris and globules.

(C) At the equator (E) the lens capsule is detached. The thickened endothelium is an artefact. The germinal zone is partially preserved. Posteriorly, at (G), there is a group of pathologically proliferated germinal cells, which resembles a giant cell. The lens substance (S) is broken up. At (F) a broad zone of fragmented lens fibers stands out conspicuously.

The effect of a swollen vitreous on the recessus hyaloideocapsularis was interesting (figs 6 and 7) Normally, the triangular space external to the hyaloid ligament faces laterally, but here it faces anteriorly because of the great bulge of the anterior limiting layer of the vitreous Also, normally the limiting layer presses so lightly on the zonular system as to protrude but slightly between the different fibers Figures 2 and 3 show the anterior limiting layer so strongly compressed between the fibers over the flat part of the ciliary body as to be sharply fluted, causing the fibers to be embedded in deep furrows Such an arrangement is possible only when the vitreous, because of increased volume, causes strong pressure in all directions

#### GENERAL COMMENT

As opacities in the lens of a glaucomatous eye are almost sure to increase, their presence forms a deciding factor in the type of operation to be selected for reducing the tension Clinical and pathologic experience prompts me to warn against two operations An extensive cyclodialysis frequently favors the more rapid development of the cataract and not rarely leads to insidious iritis, which is hard to counteract because atropine must be used cautiously As to trephining, after such an operation the ciliary processes are often fixed to the scar and when, in the extraction of a cataract, they are cut through an extensive hemorrhage is apt to ensue, followed by a membranous formation, and possibly by sympathetic ophthalmia

To differentiate between failing vision due to progressive cataract and failing vision due to progressive glaucoma, it is imperative that the tension be recorded and the fields be plotted from the very start of the treatment If an eye has already been operated on for the relief of glaucoma, and it is considered desirable further to reduce the tension by extracting the cataractous lens, it is well to remember that a glaucomatous eye, once operated on, will stand a tension of about 30 mm, taken with a Schiötz tonometer, better than an eye with the same tension which has not been operated on Finally, a glaucomatous eye after operation is not very subject to an acute attack, whereas an eye not operated on stands always under the menace of such an attack

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## TREATMENT OF SUBCHOROIDAL HEMORRHAGE BY POSTERIOR SCLEROTOMY

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IN 1915 Verhoeff<sup>1</sup> reported saving an eye in which an expulsive subchoroidal hemorrhage had developed after a filtering operation for chronic noninflammatory glaucoma. This was the first report of successful retention and maintenance of function of an eye after expulsive hemorrhage, and it is to Verhoeff that credit is due for a method of dealing with this disaster.

It was not until 1938 that Vail<sup>2</sup> reported the second and third cases of successful management of expulsive subchoroidal hemorrhage. He employed Verhoeff's method of sclerotomy as soon as possible after the diagnosis was made. In his first case reported the hemorrhage occurred after intracapsular extraction of cataract, in the second, after a Graefe knife section preliminary to iridectomy for chronic noninflammatory glaucoma.

Since Vail's report, there has been no further recorded instance of an eye with useful vision being saved after this type of postoperative complication. Samuels,<sup>3</sup> in reporting on 8 eyes studied microscopically, advocated Verhoeff's method of attack on the problem. Expulsive subchoroidal hemorrhage is greatly feared, and in general when it happens the ophthalmologist bandages the eye for several days and then enucleates.

The following case is summarized in some detail in order to stress our experience while dealing with a supposedly destroyed eye.

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From the Department of Ophthalmology, University of Wisconsin Medical School.

1 Verhoeff, F. H. Scleral Puncture for Expulsive Subchoroidal Hemorrhage Following Sclerostomy. Scleral Puncture for Post-Operative Separation of the Choroid, *Ophth. Rec.* **24** 55 (Feb.) 1915.

2 Vail, D. Posterior Sclerotomy as a Form of Treatment in Subchoroidal Expulsive Hemorrhage, *Am. J. Ophth.* **21** 246 (March) 1938.

3 Samuels, B. Post-Operative Non-Expulsive Subchoroidal Hemorrhage, *Arch. Ophth.* **6** 840 (Dec.) 1931.

## REPORT OF A CASE

A white man aged 54 entered the Wisconsin General Hospital complaining of progressive loss of vision during the past ten years. Thirteen years previously he was struck in the left eye with a chip of wood, after which objects seen with this eye appeared double and triple. Examination of his eyes revealed cataracts of the sclerosed type, in addition, the left eye had a dense gray anterior subcapsular plaque, 3 mm in diameter. The fundi could not be seen well enough for description. Intraocular tension was 15 mm in the right eye and 19 mm (Schiotz) in the left eye. On May 5, 1944 a combined intracapsular cataract extraction was done on the right eye. On the seventh postoperative day a small hyphema was noted, and three days later the diagnosis of choroidal detachment was made. Subsequently, the eye healed well, and vision of 20/20 with correction was obtained. Examination of the fundus revealed a linear patch of healed choroidoretinitis along the superior nasal vessels.

On Sept. 29, 1944 a combined extracapsular cataract extraction was done on the left eye. The eye was opened by making a section at the limbus with the keratome, enlarging it with scissors. Liquid vitreous was observed escaping from the wound, its loss producing a soft globe even before iridectomy. Attempted intracapsular delivery of the lens was made difficult by the softness of the globe, and capsulotomy resulted. The lens was then delivered with a loop to prevent its sinking into the vitreous cavity.

During the tying of the corneoscleral and conjunctival sutures the patient began to complain of acute pain in the eye. Nausea developed, and his skin became cold and clammy. It was noted, too, that the globe had become very hard and the wound began to gape. The interior of the eye appeared entirely black. The symptoms and signs pointed unquestionably to subchoroidal hemorrhage, and light projection tests then revealed response far in the temporal field only. A Graefe cataract knife was thrust through the globe in the inferior temporal quadrant 12 mm from the limbus, immediately releasing a large amount of bright blood. Holding the knife twisted in the scleral wound resulted in evacuation of a diminishing stream of blood, though on removal of the blade the eye soon became very painful and stony hard and the conjunctival sutures taut.

The process of reinserting the knife into the scleral wound and releasing the blood was repeated at least six times, at the end of which the bleeding appeared to be stopped. It was estimated that at least 30 cc of blood was drained from the eye during a half-hour period. Atropine was instilled and a gentle pressure bandage applied.

Postoperative healing of the eye was surprisingly good. The globe was moderately injected, and the anterior chamber contained considerable soft lens matter but no blood. Sanguineous drainage was slight. On the sixth postoperative day light perception had returned in the nasal field. On the nineteenth postoperative day details of the fundus could be seen well enough to determine that the choroid and retina were in normal position. The patient left the hospital on October 27.

Observation made on March 24, 1945 revealed that the left eye was quiet, with deep anterior chamber and a thin secondary cataract, through which details of the fundus were easily seen. There was a wide patch of healed choroidoretinitis along the superior temporal vessels similar to that seen in the right fundus. Macular pigment was clumped and granular. The right visual field was normal, the left had fair vision for form but no color vision. Intraocular tension was 15 mm in the right eye and 15 mm (Schiotz) in the left eye.

Visual acuity was 20/15 in the right eye with a correction of 9.25 D sph  $\ominus$  + 2.00 D cyl, axis 20 and 20/100 in the left eye with a correction of 6.00 D sph  $\ominus$  + 6.00 D cyl, axis 180

The cause of the bilateral choroidoretinal scars is obscure. As a rule choroidal detachment heals without producing marked disturbance in the fundus picture. The scars in the left fundus could have been produced either by the initial injury thirteen years earlier, which undoubtedly caused lasting complications, or by the operative complications.

#### COMMENT

Diagnosis of the expulsive type of subchoroidal hemorrhage is not difficult. The sudden severe pain, and the pallor, clammy perspiration and nausea associated with a rapidly hardening eyeball are unmistakable signs. It should be emphasized that the patient repeatedly complains of his discomfort during the rapid rise of intraocular tension. By quickly determining the light projection, the surgeon is aided in choosing the site for sclerotomy. Samuels<sup>3</sup> pointed out that the largest mass of blood is most often found on the temporal side, and anteriorly rather than far posteriorly.

Prophylactic measures, as advocated by Ziegler<sup>4</sup> and Samuels<sup>3</sup> and reviewed by Vail,<sup>2</sup> should not be overlooked, but the problem of anticipating subchoroidal hemorrhage is anything but easy. It is not to be denied, however, that surgical subchoroidal hemorrhage is a distinct threat in the fellow eye after it has occurred in the first eye.

Regan<sup>5</sup> reported the successful use of venesection following a "less violent" choroidal hemorrhage, but stated that the expulsive type "offers little or no opportunity for therapy of any kind."

The severity of the choroidal hemorrhage in the present case may perhaps be contested, since the ocular contents were not prolapsed, yet the course of events and the immediate evacuation of large quantities of blood on opening the sclera are proof of the type of complication. Only the lack of time and a tightly sewed wound prevented completion of the expulsive process.

It is our conviction that sclerotomy should be tried in instances of expulsive choroidal hemorrhage and the results reported, so that ophthalmologists may be better equipped to deal with this usually disastrous event.

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4 Ziegler. The Problem of Choroidal Hemorrhage in Cataract Extraction, in *Contributions to Ophthalmic Science*, Menasha, Wis., George Banta Publishing Company, 1926, p. 7.

5 Regan, J. J. Venesection in a Case of Choroidal Hemorrhage Following Cataract Extraction, *Am J Ophth* 26:534 (May) 1943.

## LABILITY TEST FOR CHRONIC SIMPLE GLAUCOMA

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THE IMPORTANCE of chronic simple glaucoma as a cause of ocular disability and blindness is unquestioned. It is fortunate that newer pharmacologic developments and widening surgical experience have provided therapeutic measures that in many cases prove effective in controlling the insidious progress of this disease.

However, before effective therapy can be employed, the diagnosis of chronic simple glaucoma must be made with some degree of assurance. This is so because the proper treatment of the disease involves either surgical intervention or an indefinite period of medication, or both, and lifelong ophthalmologic surveillance. Such a regime, obviously, is not one to which the patient can be subjected lightly. However, the constant threat of danger from the disease if present requires the institution of treatment at the earliest possible time, and a prolonged period of diagnostic observation without therapy cannot be condoned. It is obvious, therefore, that a quick and certain method for the diagnosis of chronic simple glaucoma is greatly to be desired.

Such a diagnosis is established without difficulty when in a quiet eye the intraocular pressure is found to be above the normal range or advanced signs of glaucoma are present, such as prominent excavation of the nerve head or typical changes in the visual field. In eyes presenting such signs the course of the disease has usually advanced sufficiently to reveal its presence by the irreversible damage it inevitably produces if uncontrolled. There are, however, patients who consult the ophthalmologist because of ocular symptoms that suggest the presence of chronic simple glaucoma, but who have normal ocular tensions even on repeated office examinations. Such patients may show either no functional or anatomic signs of glaucoma or insufficient evidence for the diagnosis of the disease. The diagnostic challenge such patients present is important, since the absence of definite evidence of chronic simple glaucoma does not eliminate the possibility of that disease being present in a mild or an early stage. At such a time the need of proper diagnosis and treatment of the condition is urgent to prevent the insidious occur-

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rence of more advanced ocular damage. Because of the frequent difficulty in diagnosing early chronic simple glaucoma, several ingenious diagnostic procedures have been devised. Those which attempt to demonstrate the presence of the disease by causing an abnormal elevation in ocular tension are often referred to as provocative tests.

Fundamentally, the purpose of such tests is to throw a strain on the mechanism whereby normal ocular tension is maintained within a physiologic range. A consideration of the many unrelated factors which must be integrated to produce a homeostatic level of intraocular pressure has led many observers to conclude that such control must exist. While its exact nature is still uncertain, it seems likely that some disturbance in such a regulatory system is present in chronic simple glaucoma. The presence of such a pathologic disturbance may be demonstrated by any method whereby a sudden strain is thrown on the mechanism of control of tension. In such circumstances, a faulty regulation of ocular tension manifests itself in an abnormal rise of intraocular pressure. In non-glaucomatous eyes the normally effective control of tension is demonstrated by a less labile variation in pressure.

The older provocative tests now commonly employed for the diagnosis of chronic simple glaucoma, such as the dark room test, the caffeine and water-drinking tests and the use of mydriatics, have proved of limited value because the elevations in ocular tension that they produce when the result is "positive" are often not distinctly abnormal, and their "negative" results are frequently unreliable. In other words, the strain they place on the regulatory mechanism of ocular tension is often too small, or too inconsistent in effect, to be of diagnostic value. The need for a more reliable provocative test than the methods usually employed is thus apparent.

About a year ago, Dr. Robert K. Lambert and I<sup>1</sup> devised a method whereby the effectiveness of the control of tension in any eye could be quantitatively indicated and defective regulation indicative of chronic simple glaucoma be readily demonstrated. Our method was based on the following reasoning:

The enveloping structures of the globe are reasonably inelastic, and the formed elements within the eye have a relatively constant volume. The most important factors in determining the intraocular pressure at any time, therefore, are the variations in volume of the intraocular fluids. The amount of fluid within the eye depends primarily on the intraocular blood flow. It therefore seemed probable to us that the induction of a transient vascular congestion in the eye would tend to produce a significant elevation in tension that would be most pronounced if the normal controlling mechanisms were pathologically defective.

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<sup>1</sup> Bloomfield, S., and Lambert, R. K. The Lability of Ocular Tension, *Arch Ophth* 34: 83 (Aug) 1945.



After prolonged study, we devised a procedure whereby such transient intraocular hyperemia could be safely produced. Appreciable increases in ocular tension resulted, which were significantly greater in eyes with chronic simple glaucoma. We called our method the lability test because its purpose is to measure quantitatively the lability of tension in any eye and, accordingly, to demonstrate the presence of a defective regulation of pressure associated with chronic simple glaucoma by causing transiently an abnormal rise in intraocular pressure.

Basically, the lability test consists in the simultaneous application of the cold pressor test of Hines and Brown<sup>2</sup> and the jugular compression test described by Schoenberg.<sup>3</sup> The principle of the cold pressor test is that elevations in systemic blood pressure are produced by sudden applications of cold to the body. Our studies<sup>1</sup> showed that in such circumstances a transient increase in ocular tension occurred simultaneously, suggesting an increased flow of blood into the eye. Furthermore, these increases in ocular tension were not proportional to the increase in systemic blood pressure with which they were associated. Compression of the jugular veins by pressure on the neck interfered with the outflow of blood from the eye. Our published study<sup>1</sup> has shown that neither of these procedures alone produces sufficiently consistent or appreciable effects on intraocular pressure to be of diagnostic value. However, the combination of the two has provided a diagnostic test of great effectiveness in our experience, and one that is applicable to all eyes regardless of the width of the angle of the anterior chamber. However, it must be emphasized that the diagnostic value of the lability test has been studied only in cases of chronic simple glaucoma. There is evidence to indicate that in cases of acute congestive glaucoma the test when applied during the interval between attacks may demonstrate a normal lability of intraocular pressure.

#### THE LABILITY TEST

The lability test is performed by first measuring the tension of each eye to be studied. The patient then places one open hand up to the wrist in ice water. Simultaneously, a blood pressure cuff previously placed loosely about the neck is inflated to a pressure of 50 to 60 mm of mercury, as indicated on the attached manometer. At the end of exactly one minute, the ocular tension is again recorded, with the hand still in ice water and the cervical pressure undiminished. Then the hand is withdrawn, the pressure cuff is removed, and the test is over, unless a repetition is desired for purposes of accuracy.

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2 Hines, E. A., Jr., and Brown, G. E. Standard Test for Measuring Variability of Blood Pressure. Its Significance as Index of Prehypertensive State, *Ann Int Med* **7** 209 (Aug.) 1933, Cold Pressor Test for Measuring Reactibility of Blood Pressure. Data Concerning Five Hundred and Seventy-One Normal and Hypertensive Subjects, *Am Heart J* **11** 1 (Jan.) 1936.

3 Schoenberg, M. J. Artificial Induction of Ocular Hypertension by Compression of the Jugular Veins. Its Physiologic Aspect, *Arch Ophth* **1** 681 (June) 1929.

Our studies have shown that the response of any eye to the lability test is almost always qualitatively consistent in repeated performances of the test, although numerically the increase in tension in any eye often varies with repetitions of the test. In other words, if the original result is abnormal, subsequent performances of the test will also tend to give abnormal responses, though the actual increases in tension may vary. The tension in all cases returns to its original level within two or three minutes. Figure 1 shows the setup for the actual performance of the test, except that the hand should be immersed in the ice water up to the wrist, rather than incompletely, as shown.



Fig 1—Preparation of the patient for the performance of the lability test

At the Mount Sinai Hospital this procedure has been performed on over 300 patients, without any serious complaint or undue discomfort. Old patients and patients with hypertension have been subjected to it without a single complication. The actual test requires only a minute, it is easily performed in the office or in the hospital room, and only a few technical points must be remembered. One is that the water must be ice cold, and for that purpose chipped ice or ice cubes are usually placed in the water for about fifteen minutes before use. It is also necessary that the bladder in the pressure cuff be applied anteriorly on the neck, so that both jugular veins are compressed simultaneously, without protection from surrounding structures. Furthermore, the pressure must be maintained at just below 60 mm of mercury until after the tension is recorded, which should be at the end of exactly

one minute. The patient can breathe easily with such pressure about the neck, and, of course, at such levels arterial circulation is unimpeded. Although some reddening of the face occurs, no real discomfort is present. Finally, for purposes of diagnosis, the test is performed only on eyes not under the influence of miotics.

#### OBSERVATIONS

In our original paper,<sup>1</sup> we showed that if in any eye this procedure produced a rise in ocular tension of more than 9 mm of mercury (Schjøtz) the diagnosis of chronic simple glaucoma was strongly suggested. Moreover, if the height, or ceiling, to which the ocular tension rose in the tested eye exceeded the normal limit of 30 mm of mercury (Schjøtz), whether or not the actual rise in tension was more than 9 mm of mercury, such a diagnosis was even more conclusively indicated.

Figure 2 illustrates the responses to the lability test of 77 eyes without any history or signs of chronic simple glaucoma. The average age for

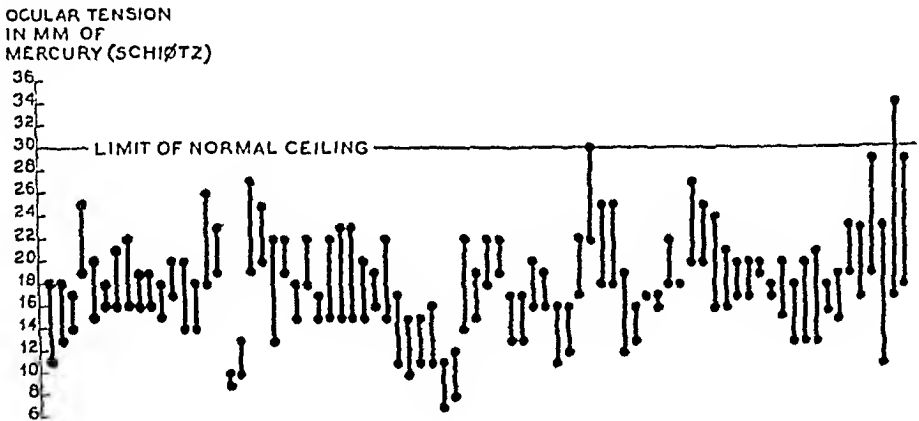


Fig 2—Response to the lability test of eyes without a history or signs of chronic simple glaucoma. Each vertical line shows the response of a single eye in this series. The bottom of each of these lines indicates the level of tension when the test was begun, and the top of each line, the height or ceiling to which the tension rose. The length of each vertical line, therefore, demonstrates the actual rise that occurred in each eye.

the patients in this group was 48, and all but 8 of the subjects were more than 35 years old. Thus, the age level of these patients was comparable to that of the group with chronic simple glaucoma. Many of the eyes in this nonglaucomatous category had varying degrees of cataract formation, some presented postoperative aphakia, and the majority had no apparent abnormality. There was no consistent difference in response of any of these types of nonglaucomatous eyes.

As figure 2 graphically shows, in only 4 of these 77 nonglaucomatous eyes did the rise in tension that occurred in response to the lability test exceed 9 mm of mercury. The vertical lines for these 4 eyes appear at the right of the chart. Even more significantly, in only 1 eye, that in which the greatest increase in tension occurred, was the level raised to

over 30 mm of mercury (Schjøtz), indicating a definitely abnormal result. In 1 other eye the tension rose to exactly 30 mm of mercury (Schjøtz), a result which would be interpreted as suggestive, but not definitely indicative, of the presence of chronic simple glaucoma.

In figure 3 are shown the results of the lability test when applied to 29 untreated eyes with known chronic simple glaucoma, which were tested when the tension without use of drops was within normal range, that is, below 30 mm of mercury (Schjøtz). Thus, the results for these 29 eyes simulated the results for eyes in which the presence of glaucoma is suspected but uncertain because the tension is normal. This is the circumstance for which these diagnostic tests are specifically designed. As shown, the lability test raised the level of tension in each

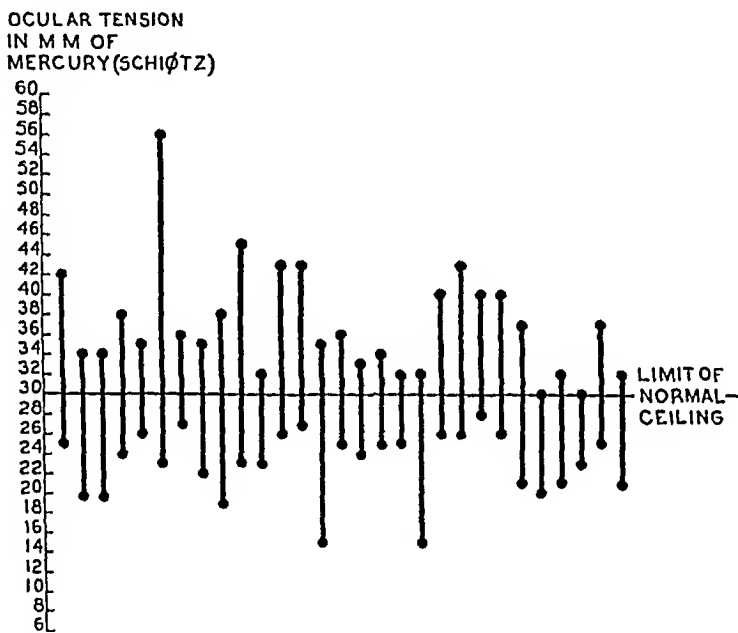


Fig 3—Response to the lability test of untreated eyes with chronic simple glaucoma but with ocular tensions normal at the time of the test. Each vertical line shows the response of a single eye in this series, as in figure 2.

of these glaucomatous eyes transiently to the level of 30 mm of mercury or more (Schjøtz). In the 2 instances in which the tension rose to exactly 30 mm of mercury (Schjøtz) the result would be considered suggestive of the presence of chronic simple glaucoma. In the remaining 27 eyes in this glaucomatous series, the tension rose above the normal ceiling of 30 mm of mercury (Schjøtz), indicating more definitely the presence of that disease. It should be recalled that in figure 2 it was shown that such an abnormal result occurred in only 1 of 77 comparable nonglaucomatous eyes.

These studies on the lability test have been concerned exclusively with its possibilities in the diagnosis of chronic simple glaucoma. In a small number of cases, the test was applied to eyes subject only to recur-

ring attacks of acute congestive glaucoma. The results for these eyes gave some indication that the reaction of such eyes during quiescent periods is normal, and so differs from that of eyes with chronic simple glaucoma. However, further experience will be required to establish such a distinction, if valid. Similarly the response to this procedure in eyes with secondary glaucoma awaits clarification. At present the lability test is used to establish the diagnosis only of chronic simple glaucoma.

#### SUMMARY AND CONCLUSION

There is a need of a more reliable test to reveal the presence of early chronic simple glaucoma.

The lability test is a simple and quick procedure devised for that purpose.

A study of its results when applied to a series of eyes with chronic simple glaucoma and to another group without that condition indicates that it is a highly reliable test for that disease.

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## MODIFIED SNELLEN SUTURE FOR PROLAPSED CHEMOSED CONJUNCTIVA

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AND  
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WHILE ectropion is a common condition with a large number of corrective surgical procedures, an extreme degree of ectropion resulting in prolapse and chemosis of the conjunctiva is rare and constitutes a perplexing problem for the ophthalmic surgeon. The following report of a case presents a technic, hitherto undescribed, for treating the chemosed, everted, exposed conjunctiva of the lower lid.

### REPORT OF A CASE

*History*—J R, 49 year old white man, fell off a tugboat on Feb 2, 1945, was unconscious for eighteen hours, and was treated at another hospital. He had sustained occipital and parietal fractures of the skull, intracranial arteriovenous aneurysm, bilateral exophthalmos, fourteen fractured ribs and a fractured right scapula. On May 30, 1945, the right internal carotid artery was occluded by application of a Michel clip for the arteriovenous aneurysm. The intracranial bruit disappeared. Forty-eight hours later, the patient developed eversion and prolapse of the conjunctiva of both lower eyelids. He was discharged at this time because it was felt that further treatment would be of no value. Vision uncorrected was reported as 20/70 in both eyes.

On admission to this hospital, vision of the right eye was 20/25, not correctible, of the left eye, 20/20. Tension was normal. There was bilateral exophthalmos, more marked on the right. The left pupil was somewhat larger than the right, but both reacted to light. There were pronounced hypertrophy and chemosis of the conjunctiva of each lower fornix. The conjunctival vessels were congested, more so on the right. The right fundus revealed a congested disk with full tortuous veins, scattered hemorrhages and some edema in the surrounding retina. The left optic disk appeared to have temporal pallor. There was no audible bruit over the skull. Slight weakness of the right external rectus muscle was noted. Perimetric study showed minimal contraction of the right peripheral field. Roentgenograms of the orbits and skull revealed no evidence of fracture or of suggestive increased intracranial pressure.

*Operative Procedure and Course*—The cornea and conjunctiva of both eyes were anesthetized with tetracaine hydrochloride, 0.5 per cent. Cotton pledgets

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From the Veterans Administration Hospital

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saturated with equal parts tetracaine hydrochloride, 0.5 per cent, and 1:1,000 solution of epinephrine were applied to the prolapsed conjunctiva of both eyes for five minutes. This resulted in some reduction of the chemosis, and the conjunctiva could be inverted. However, this did not hold. Using a double-armed 3-0 black silk suture, a horizontal mattress suture was inserted into the conjunctiva at the junction of the inner and middle thirds 10 mm from the lid margin. Each arm of the suture was then carried through the periosteum of the inferior orbital ridge and out through the skin of the cheek. A similar mattress suture was made at the junction of the middle and outer thirds. The sutures were then pulled down-

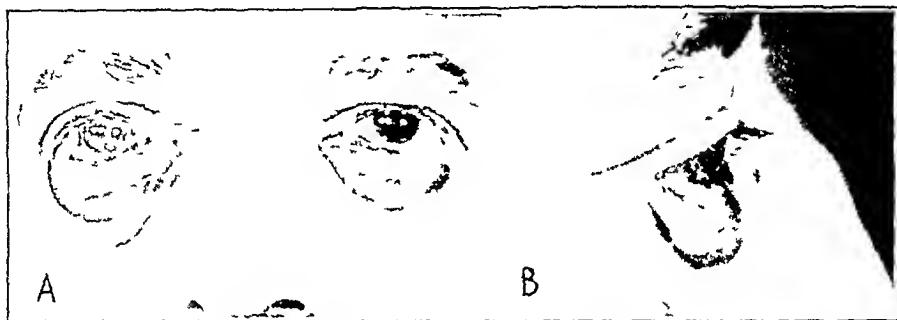


Fig 1—*A*, front view of eyes showing hypertrophied, prolapsed, chemosed conjunctiva of lower eyelids before operation, *B*, lateral view



Fig 2—*A*, front view of eyes eighteen days after operation, *B*, lateral view

ward, thus inverting the prolapsed conjunctiva and reforming the inferior cul-de-sac. The sutures were tied over a roll of absorbent cotton. The same procedure was used for both eyes. The eyes were well lubricated with boric acid ointment. Two traction sutures were inserted above the margin of each upper lid, and with these sutures the upper lid was drawn down over the lower lid and held in place with strips of adhesive tape. Eye pads were applied and secured with Scotch tape.

On the sixth postoperative day, there was indurated edema with tenderness of the right lower eyelid. The sutures were removed. Penicillin, 50,000 units, was injected intramuscularly, every three hours, eight times a day, for four days. The inflammation subsided completely. On the eleventh day, slight entropion of the

left lower eyelid was noticed. It was treated by applying a strip of adhesive tape vertically on the left lower eyelid and cheek so as to evert the lid enough to keep the cilia off the globe. This was continued for five weeks before the entropion was cured. The patient was discharged after ten weeks in the hospital, on reexamination, two months later, the condition was the same.

*Comment*—The original Snellen<sup>1</sup> suture for ectropion uses two horizontal mattress sutures at the edge of the tarsus nearest the margin of the eyelid. One is placed at the junction of the outer and middle third, and the second, at the junction of the inner and middle third of the conjunctiva. Each arm of the two sutures is carried down through the eyelid behind the tarsus, and is brought through the skin 2 cm below the margin of the lid and about 3 mm apart. The sutures are tied over a gauze or cotton roll, and left in place from six days to three weeks. For this patient the procedure was modified because of the marked prolapse of the conjunctiva and the lack of an inferior cul-de-sac. It became necessary to modify this procedure to form an inferior fornix. According to Whitnall,<sup>2</sup> the distance from the margin of the lower lid to the inferior conjunctival fornix in the eyes in the closed position is 9 to 12 mm. The conjunctival sutures were therefore inserted 10 mm from the margin of the lower eyelid to form the inferior conjunctival fornix this distance from the margin of the lid.

After the operation, there was still some redundancy of the conjunctiva nasally. Further surgery was discussed with the patient, but he refused because he was planning to return to France.

#### COMMENT

A new operative procedure, a modification of the Snellen suture for ectropion, was used successfully in the treatment of prolapsed chemosed conjunctiva of the lower eyelids.

This procedure has the twofold purpose of restoring the prolapsed conjunctiva and of reforming the inferior fornix.

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1 Snellen, H. Cong. internat. d'opht., Paris, 1869.

2 Whitnall, S. E. Anatomy of the Human Orbit and Accessory Organs of Vision, ed. 2, New York, Oxford University Press, 1932.



## OFFICIAL COLOR SENSE CONTROL IN SWEDEN

C G BOSTROM, M D

AND

I KUGELBERG, M D

STOCKHOLM, SWEDEN

**D**URING the last ten years official color sense control in Sweden has been well organized, about this we shall give a short account

The control is divided into two stages. In the first stage any medical practitioner with a normal color sense may perform the examination. The second stage is of a more scientific nature, as the examination is made by ophthalmologists with special training and approved by the board of directors of the Medical Department. The latter stage is concerned with complicated or doubtful cases, and in this stage must also be established the quality and degree of the defect in the color sense.

Naturally all necessary methods will be used in the second stage examinations, i. e. not only different pseudoisochromatic plates, but also spectral apparatus (Nagel, Gothlin) as well as test lanterns (the Eldridge-Green color perception lantern and Kugelberg-Karpe's so-called contrast lantern), etc. Examinations in the first stage are made with pseudoisochromatic diagrams only.

In 1934 Sweden officially changed to the use of pseudoisochromatic plates, it having been found that Holmgren's so-called wool tests could not be relied on, either in the hands of a medical practitioner or in those of an expert. Sweden has resolutely adhered to the use of at least two different series of pseudoisochromatic diagrams, thus making possible a confirmation of the results of the examination.

In 1934 the use of Ishihara plates was prescribed officially. Those plates, up to and including the fourth edition, had been used unofficially for a long time, and were considered to be of excellent quality. In connection with the Ishihara plates a new Swedish series, edited by Gothlin and Bostrom, "*Tabulae pseudo-isochromaticae G. B.*," became compulsory. Because of the variations in the quality of the Stilling series and the growing deterioration of the plates, they were considered no longer fit to be used. Unfortunately the later editions of Ishihara's series showed considerable imperfections, the fifth was somewhat poorer, and the sixth was still worse. In 1936 the Medical Department consequently found it necessary to forbid the use of numbers 4, 5, 10, 11 and 16 of the latter edition. The defects in Ishihara's seventh edition

were so obvious that many persons with a normal color sense were able to read the diagrams which should have been discernible only by certain color-defective persons.

In 1936 it was obvious that Ishihara's series had undergone the same deterioration which long before (1915) had been observed in the Stilling series

During the war importing of Ishihara's series was stopped, so in 1942 the Medical Department was obliged for the time being to permit the issue of color sense certificates based on examinations with Gothlin-Bostrom's pseudoisochromatic diagrams only. In 1944, however, we published a new Swedish series of color plates: "Tabulae pseudoisochromaticae B K". In the same year it was accepted for first stage examinations in connection with the pseudoisochromatic diagrams of Gothlin and Bostrom. Thus the old goal was once more attained, i.e. the simultaneous use of two different series pseudoisochromatic plates. A brief account of the new diagrams follows.

The series consists of twenty plates, seventeen of them for diagnostic purposes and three of them without numerals or figures. The latter three serve to disclose dissimulation. An instruction plate (as for instance Ishihara's first one) was not considered necessary. The plates are of the same size as Ishihara's and are also fixed on a so-called Leporello carton. The diagrams show round, colored spots, all of them with a diameter of 2.5 mm. In all diagrams except two, the mutual position of the spots is the same. For technical reasons it has been necessary to turn the background of those two 90 degrees. On 15 of the diagrams there is a figure and in 2 a serpentine line. The numerals or figures as well as the background are produced in three different degrees of luminosity toned to each other. It has been found that this renders the task more difficult for a color-defective person, while a normal one scarcely is distracted by it.

As to the color selection, simple confusion colors have been used only. Thus every diagram contains only two colors, each in three different degrees of luminosity.

The purpose of the new diagrams is to detect all types of color defects, except the tritanopsic and the tritanomalous. These are very rare and also have no practical importance as far as colored traffic signals are concerned. No less than fifteen different confusion colors have been composed in order to cover as many variations as possible of the anomalous trichromat. While yet in print the series was proof read by persons whose scientific type of color defect previously had been established by spectroscopic examinations. As will be seen from the foregoing, Ishihara's method of using figures only to be perceptible to color-defective persons has been discarded. However fascinating and pleasant to the routine examiner Ishihara's "pseudo-figures" may be, experience has

unfortunately shown that these figures often are unreliable, causing uncertainty in the exact estimation of the color sense. As a matter of fact, not only color-defective persons but also normal ones read the figures which should be perceptible only to patients with defective color vision. To a certain extent this is evidently due to the fact that these plates are too dependent on the content of short wave light as well as on the testee's state of adaptation. By the exclusion of the "pseudo-figures," the dependence on the quality of the light decreases. Naturally all diagrams have to be shown in daylight or in the light of a good daylight lamp.

The time of exposure for every plate must not exceed fifteen seconds. In most cases, however, a considerably shorter time is sufficient. It sometimes happens that a color-defective person at first perceives the figure for a moment, but that it vanishes on further observation. In case of obvious difficulty to make out a figure, the patient is allowed to try to point out the figure. In this manner a color defect is often revealed.

As to the estimation of the color sense, the inability to make out two diagrams means defective color vision. The inability to perceive one diagram means that the color sense must be looked on as doubtful. The patient must then be subjected to further examinations with spectral apparatus and other methods (i. e. the second stage) in order that a decisive conclusion may be drawn.

The diagrams are not made with a view to a diagnosis of the quality of the color defect. This is not possible with any degree of certainty with pseudoisochromatic diagrams only, on the other hand, an exact classification is in most cases without importance. Neither is it advisable to base an exact estimation of the character of a defect in color vision on the examination with pseudoisochromatic plates only. A complementary examination in the second stage also is necessary.

It is well known that simulation of color blindness is rare while attempts at dissimulation of defects of color vision are the more common. To make dissimulation more difficult, certain plates have been added. Furthermore, the pattern of most of the plates has been made in the same way. Moreover, the arrangement of the plates should be changed from time to time, the 6's and 9's should be inverted, etc.

The pseudoisochromatic plates of Bostrom and Kugelberg have been made in half tone print, which probably is a novelty. The plates have been exposed to ultraviolet rays, showing that they have fast colors. Finally, it may be mentioned that Kirurgiska Instrument Fabriks A. B., Kista-Stockholm, has the copyright for the new series.

# Clinical Notes

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## A RADICAL INNOVATION IN CONTACT LENSES

JOSEPH I. PASCAL, M.D.  
NEW YORK

From the time of the earliest anatomic studies the eye has been described as practically a sphere, an idea which is reflected in the term eyeball. When the idea of making contact lenses to fit directly on the eye arose, it was but natural, therefore, that a globular shell was assumed to be the proper form. Blown contact lenses were designed to approximate a sphere. The first sets of ground glass contact lenses were all made as sections of a sphere, the different sizes being sections of spheres with different radii.

Many eyes were fitted comfortably with these spherical contact lenses, but a great many others could not be fitted satisfactorily. It was soon discovered that, minutely considered, the average eye was far from a regular symmetric sphere and that in most instances the spherical lens sat ill on a nonspherical eye. The next stage was to consider the eye, at least the anterior section of it, as part of a toric surface having two spherical curves at right angles to each other. Many eyes were found to conform to this shape, and contact lenses made on the toric principle satisfied many patients. But here, too, it was soon found that the majority of eyes did not fall into this toric pattern and that lenses fitted on the toric principle satisfied relatively few patients.

A significant step forward was made when Dr. Dallos developed the molding technique. On the face of it, it seemed that a lens made to a mold of the eye would provide the ideally fitting lens. Experience, however, has shown it to be otherwise. It may be added that Dr. Dallos in his early work felt that a mold taken of the eye in one position was not adequate. He took five molds of each eye: one mold of the eye in the primary position and then one with the eye turned in each of the four cardinal directions. He then made a composite mold from these five molds. However, lenses made from the composite mold or the single mold did not in general fulfil the expectations.

At best the mold is only an approximate replica of the living, natural eye. Lenses made from molds generally exert too much pressure on the eye and almost always have to be repeatedly modified, tightened, loosened, and so on, in an effort to make them comfortable. With all that there are a great many failures. Curiously, a contact lens which by repeated adjustments is made to have a "glove fit" on the eyeball is sometimes even more uncomfortable than was the original, more or less ill fitting or loosely fitting lens.

An experimental study as to what kind of curve would best fit the great majority of eyes brought to light the almost unexpected emergence of the cone. It was found that if the scleral section was part of a cone, and the angle of the cone was so chosen that it rested tangentially against

the eyeball a minimum of pressure was exerted. Instead of a large bearing surface between lens and sclera, it was found that sometimes a narrow tangential band 1 to 3 mm wide set inside the edge of the lens gave more comfort than any other surface. To prevent the lids from hitting against the temporal margins of the lens, the temporal portion of the tangent cone lens is provided with a flange, a small section of a sphere which merely rests against the eyeball. The adherence of the lens onto the sclera is accomplished by the conic section of the scleral part of the lens, which also allows a small dynamic lag of the lens when the eye is turned in different directions.

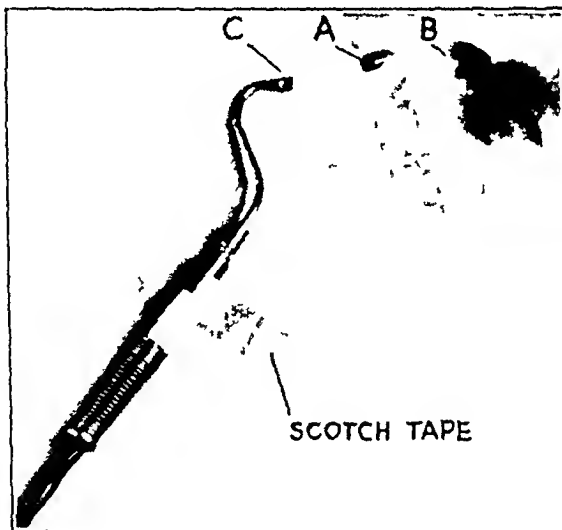
The problem of contact lenses has not yet been completely solved. For that matter, what problem in applied visual optics has been completely solved? But the introduction of the tangent cone lens marks a significant novelty in the practical fitting of contact lenses.

37 West Ninety-Seventh Street

### DANGEROUS EXPLOSION OF TRANSILLUMINATOR

LOREN GUY, M D  
NEW YORK

A near disastrous accident occurred in my office not long ago which may interest and forewarn others. A patient consulted me regarding a detached retina. In the course of the examination transillumination of the globe was planned. The patient was put in the room



The Lancaster transilluminator showing, *A*, the tip that hit the wall at *B*, tearing off plaster and smudging the area, and *C*, the rest of the transilluminator. Scotch tape holds the parts in place for the illustration.

where this is done and the Lancaster transilluminator, which was connected to the central electric circuit, was turned on and immediately exploded. The tip of the instrument containing the bulb (*A* in the illustration) broke and hit the wall with great force, breaking the plaster and

smoking the area (*B*) If the tip had not been pointed in the direction of the wall, it might have hit the patient, my nurse or me The patient's globe would undoubtedly have been badly ruptured, and possibly the tip of the transilluminator would have entered the paranasal sinuses or even the cranium

The lesson to be learned in using such instruments is to point them in a direction in which they can cause the least damage if they explode They should be treated with the same respect as a loaded gun

40 East Sixty-Second Street

# News and Notes

EDITED BY DR W L BENEDICT

## GENERAL NEWS

**Ophthalmic Laboratory Established by Estelle Doheny Eye Foundation**—The Estelle Doheny Eye Foundation announces the establishment of an ophthalmic laboratory at St Vincent's Hospital, Los Angeles, designed to provide certain modern ophthalmic facilities badly needed in Southern California

The immediate functions of the laboratory are (1) to serve as a pathologic laboratory for the diagnosis and registration of pathologic specimens, with preparation of gross specimens and microscopic slides for ophthalmologists submitting specimens, and for the building up of a museum of pathology of the eye, (2) to serve as a bacteriologic laboratory in which diagnostic scrapings, smears and cultures can be studied, animal inoculations made and the sensitivity of organisms to various drugs and antibiotics determined, (3) to provide facilities for fundus, gross and slit lamp photography and to maintain a library of photographs and motion pictures for the teaching of ophthalmology, (4) to provide an eye bank for Southern California, with registry of potential donors and recipients (donor material will be collected, examined and distributed, and facilities may later be provided for limited instruction in corneal transplantation procedures), (5) to distribute and loan certain drugs and equipment that are not otherwise available in the community, and (6) to make available certain special equipment for radiation therapy of the eye for use outside the laboratory

Dr Alan Woods, professor of ophthalmology at Johns Hopkins University School of Medicine, Dr Cecil O'Brien, professor of ophthalmology of State University of Iowa College of Medicine, and Dr Phillips Thygeson, formerly professor of ophthalmology at Columbia University College of Physicians and Surgeons and now associate professor at the University of California Medical School, will serve on the advisory board. Dr A Ray Irvine, professor at the University of Southern California School of Medicine, will act as chairman of the original board. It is contemplated that the board will also include prominent business and professional leaders, as well as representatives from the ophthalmologic departments of local hospitals, medical schools and the ophthalmologic section of the Los Angeles County Medical Society

Dr Peter Soudakoff, formerly associate professor of ophthalmology at the Peking Union Medical College, will serve as full time pathologist at the laboratory. It is planned that, as part of the residency program of the eye service of the Los Angeles County Hospital and of certain local veterans hospitals, each resident will spend two or three months in the laboratory. It is anticipated that a research associate, granted a fellowship in basic ophthalmologic research by the Foundation, will be added to the laboratory staff from time to time

In creating this perpetual charitable foundation dedicated to the conservation and restoration of eyesight, Miss Doheny, with great generosity and discerning wisdom, has been careful to insure a flexibility of organization to take care of the immediate practical needs and, at the same time, to provide for eventual development of much needed research in ophthalmology

**Request for Ophthalmic Literature and Texts for Library in Batavia.**—Dr J C van Manen, the newly appointed head of the Department of Ophthalmology at the Medical University, Batavia, Netherlands East Indies, requests ophthalmic literature for his clinic. Robbed at first by the Japanese and later by the Indonesian Nationalists, the university library has been depleted of nearly all its books. Reprints and texts would be most welcome. To assist in the payment of shipping literature abroad, a fund has been set up by Mrs Elizabeth Proctor and is administered by Miss Jeanette Loessl, Howe Library, Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston. Books and other literature should be sent either to this address, with instructions for whom they are intended, or directly to Dr J C van Manen, Universiteit van Indonesië, Geneeskundige Facultiet, Salemba 6, Batavia-C

**Twenty-First Annual Spring Graduate Course, Gill Memorial Eye, Ear and Throat Hospital**—The twenty-first annual spring graduate course, Gill Memorial Eye, Ear and Throat Hospital, will be given the week of April 5 through April 10, 1948. Among the guest speakers in ophthalmology will be Prof Adalbert Fuchs, UNRRA-WHY, Nanking, Shanghai, China, Dr Conrad Berens, 35 East Seventieth Street, New York, Dr A D Ruedemann, Wayne University College of Medicine, Detroit, Dr Edwin B Dunphy, Massachusetts Eye and Ear Infirmary, Boston, Dr Trygve Gundersen, 101 Bay State Road, Boston, Dr John M McLean, 525 East Sixty-Eight Street, New York, Dr Alston Callahan, Medical College of Alabama, Birmingham, Ala



# Abstracts from Current Literature

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## Experimental Pathology

SOME EFFECTS OF VITAMIN-A DEFICIENCY ON THE EYE OF THE RABBIT  
I MANN, A PIRIE, K TANSLEY and C WOOD, *Am J Ophth* 29.  
801 (July) 1946

A study of biomicroscopic and histologic changes in the eyes of vitamin A-deficient rabbits correlated with vitamin A levels of the plasma substantiated the observations of earlier workers that the ocular changes are primarily in the conjunctiva and epithelium of the cornea. Keratinization of the cornea and conjunctiva clears up rapidly on treatment with vitamin A, but removal of conjunctival pigment and reestablishment of the conjunctival mucous cells take place more slowly.

W S REESE

RELATION BETWEEN MATERNAL VITAMIN-A INTAKE, BLOOD LEVEL,  
AND OCULAR ABNORMALITIES IN THE OFFSPRING OF THE RAT  
B JACKSON and V E KINSEY, *Am J Ophth* 29:1234 (Oct)  
1946

Jackson and Kinsey conclude that ocular defects occur in the young rat only when the maternal vitamin A deficiency is extremely severe—so advanced, in fact, that fetal resorption is common and normal birth is impossible.

To the extent that the physiologic processes associated with reproduction in human beings parallel those in the rat, it may be inferred that vitamin A deficiency in the mother is not a probable cause of retrolental fibroplasia.

W S REESE

## General Diseases

STEVENS-JOHNSON'S DISEASE W Y JONES, F F TALBOT and W F  
KING, *Am J Ophth* 29:185 (Feb) 1946

A case of Stevens-Johnson disease occurring in a woman aged 56 is reported. The authors believe that the name Stevens-Johnson disease should be reserved for those cases of erythema exudativum multiforme exhibiting a purulent conjunctivitis.

W ZENTMAYER

MEDICAL SIGNIFICANCE OF OCULAR TORTICOLLIS J W SMITH, *Bull  
Hosp Joint Dis* 6:99 (Oct) 1945

Ocular torticollis may be defined as a compensatory adjustment, tilt or position of the head to overcome vertical diplopia. In the diagnosis of paresis of the vertically acting muscles, the eyes of the ophthalmologist must be on the same level as those of the patient. Palpation for tightness or gross enlargement of the sternocleidomastoid muscle and examination for skeletal defects should be made. Relaxation of the patient is

best obtained by examining the patient's back. Photographs should be made against a graph for better showing of the degree of head tilt and ocular torticollis before and after operation. Interdepartmental consultations are important in the differential diagnosis of congenital and ocular torticollis. Operations for convergent and divergent strabismus should not be performed until the action of the vertically acting muscles have been studied carefully. Head tilt and other skeletal changes are presumptive evidence of vertical muscle imbalance. Smith describes a graph of his own designing.

W ZENTMAYER

### Glaucoma

PREGLAUCOMA H S GRADLE, *Am J Ophth* 29:520 (May) 1946

Gradle divides preglaucoma into two forms, that which precedes acute glaucoma and that which is followed by chronic glaucoma. They can be differentiated clinically but require different types of provocative tests for confirmation. When recognized, preglaucoma necessitates preventive treatment.

W S REESE

CYCLODIALYSIS IN THE TREATMENT OF GLAUCOMA S D McPHERSON, *Am J. Ophth* 29:848 (July) 1946

McPherson analyzed 140 cases of chronic primary glaucoma, glaucoma following cataract extraction and glaucoma secondary to uveitis, treated with cycloidalysis. Tension was brought below 30 mm of mercury (Schiotz) in 42 per cent of the cases of primary glaucoma, in 35.9 per cent of cases of glaucoma following cataract extraction and in 65 per cent of the glaucoma secondary to uveitis. The operation was more effective in eyes with deep anterior chambers, and failure to reduce the tension to normal was likely to be evident in the first post-operative month.

W S REESE

TREATMENT OF GLAUCOMA WITH DI-ISOPROPYL FLUOROPHOSPHATE (DFP) P R McDONALD, *Am J Ophth* 29:1071 (Sept) 1946

McDonald successfully controlled glaucoma with diisopropyl fluorophosphate (DFP) in 57.4 per cent of a series of 122 eyes, in which the disease had previously been uncontrolled. He found it more powerful than any other miotic and its action prolonged, it does not cause local irritation, and it appears especially effective in treatment of aphakic glaucoma.

W S REESE

POSTERIOR SCLEROTOMY AND LENS EXTRACTION IN ACUTE GLAUCOMA SECONDARY TO SENILE CATARACT P J KENNEDY, *Pennsylvania M J* 49:742 (April) 1946

Six patients with glaucoma secondary to senile cataract were treated by complete minimal posterior sclerotomy, followed in ten minutes by combined extraction of the lens. The results have been good. The method would seem to warrant further use before its value can be definitely ascertained. The main complications—hypotony immediately following the sclerotomy—can be controlled by careful surgical technic.

W ZENTMAYER

## Hygiene, Sociology, Education and History

NINETEENTH CENTURY PROVINCIAL EYE HOSPITALS (WITH SPECIAL REFERENCE TO THOSE NO LONGER EXTANT) A SORSBY, Brit J Ophth 30:501 (Sept) 1946

Records are extant of the founding of 19 ophthalmic hospitals between 1808 and 1832. Of these, 11 have survived and 8 have become defunct. The 11 survivors are now all venerable institutions, some being of considerable importance. The distribution of these 19 ophthalmic institutions shows that they were largely concentrated in the declining, but still populous, southwestern area of England and in the rapidly growing northern belt. Between 1834 and 1861, 15 ophthalmic institutions were established, and of these 6 have survived. Southwest England still claimed a considerable development, but the Midlands now figured prominently. Between 1866 and 1889, 18 ophthalmic institutions were founded, and of these 6 have survived. A brief, concise history of these institutions is given, with biographic notes on ophthalmologists connected with the institutions no longer extant. This study represents a very considerable piece of work, occupying about fifty pages of the journal.

W ZENTMAYER

OPHTHALMOLOGY IN LECTURES OF A CENTURY AGO R R JAMES, Brit J Ophth 30:658 (Nov) 1946

James gives a few ophthalmic excerpts from lectures delivered at St Bartholomew's Hospital by Abernethy. His main thesis in ophthalmology is in operative surgery. He tells of an accident to himself when riding. The horse threw up his head, and Abernethy received a pretty severe blow on the nose. Soon after having squeezed the nasal bones into their proper places, he noticed an eclipse of the third of every object on the right side. He records his observations thus: "If I saw *A-ber-ne-thy* in a bookseller's shop window, I could see *A-ber-knee*, but I could not see the *thigh* at all. Let those [who] account for it as arising from a decussation of the nerve, do it. My own opinion is, that it arises, from the *irregular actions of the retina*."

W ZENTMAYER

## Injuries

THE MANAGEMENT OF INTRAOCULAR FOREIGN BODIES IN MILITARY PRACTICE G M HAIK, Am J Ophth 29:815 (July) 1946

Haik reviews 81 cases of intraocular foreign body dealt with under wartime conditions. He emphasizes the roentgenologic and surgical methods particularly and remarks the increase in these injuries from highly mechanized warfare.

W S REESE

ARSENICAL EYE BURNS G I UHDE, Am J Ophth 29:1090 (Sept) 1946

Uhde found British BAL (2,3-dimercaptopropanol) completely effective in preventing the serious effects of lewisite (dichlorobeta-

rovinyarsine) on the eye if used within two minutes after contamination. It is less effective against mustard gas (dichloroethyl sulfide), in cases in which irrigation is indicated.

W S REESE

### Lens

OBSERVATIONS ON THE VOSSIUS RING. T GUNDERSEN, *Am J Ophth* 29:837 (July) 1946.

Gundersen reports 19 cases of Vossius ring formation, in all of which the size of the ring was practically constant. He believes that this ring is due to deposition of blood pigments during interchange of fluids through the anterior capsule of the lens.

W S REESE

### Neurology

OPHTHALMIC SYNDROMES ASSOCIATED WITH FRONTAL TUMORS. M A DIEZ, *Arch de oftal de Buenos Aires* 20:267 (July-Aug) 1945.

Tumors of the frontal lobe produce ocular symptoms which can be detected objectively by observation of the fundus and subjectively by study of the visual field.

Diez has studied 10 cases verified by operation and anatomopathologically. Their period of evolution from the appearance of the first subjective symptoms ranged from three months to nine years. Headaches and failing vision were the usual initial symptoms.

The ophthalmologic diagnosis of these tumors may be based on the following findings: moderate exophthalmos, widening of the palpebral fissures, nystagmus on extreme ocular movement, central arterial hypertension (above 50 mm), bilateral papilledema, more marked on the side of the tumor (or with changes denoting a disturbance of longer standing), diminished visual acuity and enlargement of the blindspot on the side of the tumor, incongruent contraction of the peripheral visual fields in the majority of cases and, at times, binasal or bitemporal hemianopsias and central scotoma.

The 10 cases studied are described in detail. A table with the features of each case, their retinograms and visual fields, appears in the article.

H F CARRASQUILLO

### Pharmacology

THE INFLUENCE OF VEHICLES AND FORM OF PENICILLIN AND SULFONAMIDES ON MITOSIS AND HEALING OF CORNEAL BURNS. G K SMELSER, *Am J Ophth* 29:541 (May) 1946.

Smelser found that when a sulfonamide powder is 100 to 200 mesh, decided inhibition of corneal healing occurs, this inhibition being greater with sulfacetimide than with sulfadiazine or sulfathiazole. Hydrosorb, fatty acid esters of diethanolamine with petrolatum and hydrous wool fat U S P were the least harmful of the ointment bases in inhibiting the healing of corneal burns, and this inhibition was not increased by the

addition of penicillin Solid penicillin was harmful, but calcium penicillin powder suitably diluted with lactose caused no inhibition in itself

W S REESE

### Retina and Optic Nerve

RETINAL HEMORRHAGE AS SEEN IN AN ATOMIC-BOMB CASUALTY  
K B BENKWITH, *Am J Ophth* 29:799 (July) 1946

Benkwith reports the case of a 14 year old Japanese girl who suffered excessive gamma ray irradiations, producing her clinical picture She was about 1 mile (1.6 kilometer) from the hypocenter of the atomic bomb at Nagasaki in her home, which was demolished Her fundi showed massive preretinal hemorrhages and hemorrhages into the fiber layer of the retina These were distributed around the disk and in close association with the retinal vessels for approximately 3 disk diameters peripheral to the disk Small, fluffy, white exudates were scattered about the disk and in close approximation to the retinal vessels of greater caliber She was pronounced well at the turn of the year

W S REESE

MACULAR EDEMA A J BEDELL, *Am J Ophth* 29:1228 (Oct) 1946

Bedell concludes that edema of the macular region may be the isolated expression of a local or a general tissue reaction The edema may be limited to and disappear from the macula, or it may be the precursor of an extensive retinochoroiditis or gross macular change The healed macula may show pigmented specks, white dots, heaped-up pigment, atrophy or thick scars, which may be smooth and flat, or rough and nodular

W S REESE

CHANGES IN THE ANGIOSCOTOMAS ASSOCIATED WITH THE ORAL ADMINISTRATION OF EVIPAL [SOLUBLE HEXOBARBITONE] A I FINK, *Am J Ophth* 29:1258 (Oct) 1946

In 8 of 10 subjects Fink observed a widening of the angioscotoma after the administration of 4 grains (0.26 Gm) of soluble hexobarbitone (*n*-methylcyclohexanylethylmalonylurea, or "evipal").

W S REESE

TREATMENT OF RETINITIS PIGMENTOSA WITH INTRAMUSCULAR INJECTIONS OF COD LIVER OIL V P FILATOV and V A VERBITSKA, *Am Rev Soviet Med* 3:388 (June) 1946

Filatov and Verbitska gave intramuscular injections of cod liver oil to 12 patients with retinitis pigmentosa The patients were between the ages of 15 and 50 years Rapid improvement, manifested by an increase in acuity of vision and in light sensitivity resulted in some instances after one or two injections The increase in light sensitivity after treatment with cod liver oil was superior to that resulting from

other methods, in 1 patient the light sensitivity was increased one thousand times, in another patient fifty times and in 5 patients ten times. Good results were obtained with severe chronic forms of the disease. Although the patients reported on could not be followed for a long enough period to permit final conclusions with regard to prolonged treatment or repeated injections at intervals, the parenteral use of cod liver oil in the treatment of retinitis pigmentosa proved highly effective and deserves further study.

J A M A (W ZENTMAYER)

RETINAL DETACHMENT DUE TO WAR TRAUMA H B STALLARD, Brit J Ophth 30:419 (July) 1946

This inquiry was made to find out the incidence of retinal detachment directly attributable to the effects of war missiles, the relation of this incidence to that of other types of retinal detachment occurring in soldiers serving in a field force and the comparative results of treatment and prognosis. Retinal detachment due to trauma from military missiles is rare. Twenty cases of military trauma are analyzed. In 17 cases of military trauma in which operation was performed there were 11 successes and 6 failures, in 26 cases of trauma of civilian life, 23 successes and 3 failures, in 26 cases of choroido-retinal degeneration, 26 successes and no failures, in 16 cases of cystic degeneration, 16 successes and no failures, and in 8 cases of myopia, 6 successes and 2 failures. In 1 case of military trauma the ocular damage was considered too hopeless to benefit by operation, and in 2 others spontaneous recovery occurred. The reason for the comparatively poor results in cases of military trauma are the gross intraocular damage done to eyes by the severe contusion effects of war missiles traversing the orbit or parts of the cranium and face near the orbit. The intraocular pressure is considerably reduced more than with other types of retinal detachment.

W ZENTMAYER

BILATERAL SYMMETRICAL CYSTIC DETACHMENT OF THE RETINA H B STALLARD, Brit J Ophth 30:547 (Sept) 1946

Stallard reports on 2 cases of bilateral symmetric cystic detachment of the retina, preequatorial in the upper temporal quadrant of each eye. In both cases the cysts were symmetric in size, shape and position. In 1 case the cystic detachment in the right eye had spontaneously disappeared, the retina was replaced and there was no retinal hole. The periphery of the cyst in this case was marked posteriorly by a broad, grayish white crescent, and the area of retina which had formed the thin, stretched cystic wall, and was now replaced, showed a slightly deeper red fundus reflex than the rest of the fundus. This appearance of the fundus was precisely that seen after successful reposition of the cystic detachment by surgical measures. In neither case was there any family history of cystic detachment or any congenital ocular or other defect. The eyes of both patients were normal except for the cystic detachment. One had a low degree of myopia, and the other was emmetropic. The vitreous appeared normal, and there were no congenital defects in the eyes or elsewhere in the body. A single application of surface diathermy

was made near the most dependent part of the cyst, about halfway between the equator and the ora serrata. Through this site a single puncture was made with a fine, penetrating diathermy needle 1.5 mm long. The cystic fluid was effectively evacuated, and postoperative recovery was uneventful. The retina was replaced in the 3 eyes operated on.

W ZENTMAYER

CHORIORETINITIS JUXTAPAPILLARIS (JENSEN) J. W. C. VERHAAGE,  
Ophthalmologica 111: 351 (June) 1946

The author reports a case of juxtapapillary chorioretinitis (Jensen) in which there were prominent lesions of the veins, together with deposits of cholesterol in one retina. The opposite eye also showed signs of healed periphlebitis of the retina. In the author's opinion, both the periphlebitis of the retina and the juxtapapillary choroiditis were due to a tuberculous infection. He considers the choroiditis as due primarily to periphlebitis.

F. H. ADLER

### Trachoma

SULFONAMIDES AND PENICILLIN IN THE TREATMENT OF TRACHOMA  
F. S. LAVERY, Brit J Ophth 30: 591 (Oct) 1946

Fifty-four cases of trachoma are analyzed as to the result of treatment with sulfonamide compounds and penicillin. In the cases selected for penicillin therapy the drug was administered locally in the form of drops, with a concentration of 2,500 units per cubic centimeter. Only cases in which inclusion bodies were observed, either before or after treatment, were considered. It is of importance that in 3 cases inclusion bodies were identified after carefully controlled sulfonamide therapy. On the other hand, the absence of inclusion bodies in 5 of 8 cases after the conclusion of sulfonamide therapy against their absence in 1 of 5 cases in which penicillin therapy was used can hardly be fortuitous. The sulfonamide compounds were administered internally and locally.

W ZENTMAYER

### Tumors

GLIOMA OF THE OPTIC NERVE M. MANNHEIMER, Am J Ophth  
29: 323 (March) 1946

Mannheimer reports a case of glioma of the optic nerve. Intracranial section of the nerve was first performed, followed by enucleation and extirpation of the remaining nerve.

W. S. REESE

EXOPHTHALMOS CAUSED BY EOSINOPHILIC GRANULOMA OF BONE  
M. WHEELER, Am J Ophth 29: 980 (Aug) 1946

Wheeler reports the case of a man aged 34 who had a tumor of the right orbit which had caused erosion of the roof. The growth was removed and proved to be eosinophilic granuloma of bone.

W. S. REESE

AN UNPIGMENTED PRIMARY TUMOUR OF THE OPTIC DISK J P  
WHITE and A LOEWENSTEIN, Brit J Ophth 30:253 (May)  
1946

The growth was first observed when the boy was  $7\frac{1}{2}$  years old. Vision equaled 6/36 The upper two thirds of the disk of the left eye was covered by a whitish, smooth mass of 2 disk diameters The child was intelligent, well built and well nourished At the age of 9 years the disk was covered by a grayish white, oval mass with a smooth surface The margins of the tumor were tuberous and rose steeply from the fundus (+1 D) to a height of 8 D A small portion was vascular The nasal part of the mass was covered by hemorrhages There was scattered pigment in the lower half of the fundus, with depigmented spots and superficial hemorrhages The pigment was predominantly in the deeper retinal layers The fundus of the right eye showed similar changes Histologic investigation showed a tissue consisting of large, foamy cells, the contents of which were neither fatty nor mucinous The nature of the regressive process was not determined The tumor tissue infiltrated the surrounding retina, the posterior layers of which were missing and were perhaps undeveloped There was a cavernous degeneration in a large part of the optic nerve The caverns were empty or filled with a fine foamy substance A film of subhyaloid blood covered wide areas of the retina The growth is explained as a phakoma arising from the neuroectodermal cells of the optic stalk, into which the fibers of the retinal ganglion cells grow As the two layers of the optic stalk consist of potentially pigment-producing cells (the outer layer) and nonpigmented cells (the inner layer), misplacement of either of them may be responsible for the growth of pigmented or nonpigmented phakoma of the disk The existence of both malformations can be proved The article is well illustrated

W ZENTMAYER

A CASE OF CHONDROMA BULBI A Ajo, Brit J Ophth 30:465  
(Aug) 1946

The patient, a youth aged 19, stated that the condition of the left eye had always existed Two small movable soft tumors were present in the subconjunctival tissue, both extended over the limbus and infiltrated the corneal parenchyma The eye had remained quiet until the age of 17 The growths were removed and proved to be chondroma without signs of malignancy One year later there was a recurrence, the cornea was surrounded by new growth, which infiltrated the corneal tissue The article is illustrated

W ZENTMAYER

Uvea

SYNDROME OF UVEITIS, MENINGO-ENCEPHALITIS, ALOPECIA, POLIOSIS,  
AND DYSACOUSIA R D HARLEY and E S WEDDING, Am J  
Ophth 29: 524 (May) 1946

Harley and Wedding report a case of uveitis meningoencephalitis, alopecia, poliosis and dysacusia in which actinomyces were recovered



from the aqueous and the spinal fluid. They suggest that this organism initiated liberation of pigment from the irises, which resulted in sensitization to pigment of the uveal tract, and possibly other pigmented structures. The fact that the organism was similarly obtained from the spinal fluid presents the possibility that the pigmentary disturbance was of central origin, in the region of the hypothalamus. W S REESE ,

**BILATERAL UVEITIS WITH RETINAL DETACHMENT, POLIOSIS, ALOPECIA, and DYSACOUSIA** J LAVAL, *Am J Ophth* 29:536 (May) 1946

Laval reports the case of a woman aged 42 who had difficulty in reading. Examination revealed nothing significant except for a few cells in the aqueous of each eye. She then had a pronounced increase in the hyperopia evidently from retinal edema, which eventuated in a bilateral detachment. Loss of hair, loss of hearing and uveitis then became apparent, and finally secondary glaucoma developed, which required operation on both eyes. W S REESE

**BILATERAL DETACHMENT OF THE CHOROID OF UNUSUAL DURATION FOLLOWING CORNEO-SCLERAL TREPHINE** A E P PARKER, *Brit J Ophth* 30:595 (Oct) 1946

A woman aged 56 had a history of poor health and myxedema. Vision was 6/18 in the right eye and 6/12 in the left eye. Tension was 1 plus. The fields were contracted. Under treatment with miotics vision improved and the tension was consistently about 30 mm (Schiotz). As the fields continued to contract, a trephination with a small complete iridectomy was done on the right eye and the conjunctival flap sutured with a continuous suture. A few days later the choroid was detached in the upper nasal quadrant. The separation persisted about nine months, tension was 15 mm. About four months after operation on the right eye trephination was done on the left eye, and only a peripheral iridectomy was done. The choroid became detached in the upper nasal quadrant and remained so for about five months. Tension was 12 mm. The complication has apparently had no permanent adverse effect. Parker considers that the dominant feature in this case was the low tension. It might be wise to treat glaucoma with low tension by iridencleisis or cyclodialysis. W ZENTMAYER

### Therapeutics

**USE OF HEPARIN IN TREATMENT OF THROMBOSIS OF THE CENTRAL VEIN OF THE RETINA** G CIOTOLA, *Boll d'ocul* 24:35, 1945

Thirty-five cases of thrombosis of the central vein of the retina treated with intravenous injections of 150 mg of heparin (twice daily) are reviewed. The results obtained were as follows. In 1 case central visual acuity was decidedly improved, in 5 cases visual acuity became worse, in 1 case hemorrhagic glaucoma developed, in 12 cases some degree of improvement in central visual acuity occurred. In the remaining 16 cases the condition remained stationary. G BIETTI

## TREATMENT OF RETINITIS PIGMENTOSA WITH AUTOCLAVED EXTRACT OF ALOE V SKORODINSKAYA, Vestnik oftal 25:0, 1946

Skorodinskaya observed the therapeutic effect of aqueous extract of conserved leaves of aloe on retinitis pigmentosa in 12 cases, or 24 eyes. In 8 of these cases deafness was also present. The extract was given subcutaneously, in a dose of 1 or 2 cc either daily or every other day, until a total of twenty-five to forty-five injections had been made. In 1 case the extract was used in the form of enemas (which is a convenient method in children). In 2 cases implantation of the leaves of aloe (size 3 or 4 cc) was used in addition to the injections. In 1 case an implantation of conserved heterogenous skin was added to the course of injections of extract of leaves of aloe.

In all but 1 case there were improvement of vision (from 0.1 to 0.4, from 0.2 to 0.5) and enlargement of the visual fields, in some cases in the form of islands at the periphery. Dark adaptation improved last. The treatments had to be repeated every two or three months, as vision began to decrease at the end of three months. The time of observation was from seven to eighteen months. The treatment proved to be beneficial to the general condition of the patients, producing improvement of hearing, better regulated menstrual periods, better appetite and less fatigability.

O SITCHEVSKA

# Society Transactions

EDITED BY DR W L BENEDICT

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## SECOND PAN-AMERICAN CONGRESS OF OPHTHALMOLOGY

Harry Searls Gradle, M D , *President*

Conrad Berens, M D , *Secretary*

Moacyr E Alvaro, M.D , *Secretary*

Montevideo, Uruguay, Nov 26 to Dec 1, 1945

### PREVENTION OF BLINDNESS IN THE AMERICAS

Report of the Committee for the Prevention of Blindness of the Pan-American Congress of Ophthalmology DR FRANCISCO BELGERI, president, and DR BAUDILIO COURTIS, secretary, Buenos Aires, Argentina

The committee reported on the replies that had been received from the questionnaire sent to the delegates in each country of the Western Hemisphere. From the data assembled the committee concluded that much work is to be done before a uniform program for the prevention of blindness becomes a reality. They proposed a minimum program as the first step in the prevention of blindness in the Americas and suggested that the Pan-American Congress sponsor this program through government agencies and medical groups of each country. The committee would organize as part of this plan an information bureau, where data on each local program could be assembled and material such as films, documents and pamphlets could be exchanged.

### Causes of Unocular and Binocular Blindness in the United States Navy and United States Marine Corps During World War II CAPT C A SWANSON (MC), U S N

Captain Swanson reported on 759 cases of blindness that had occurred during the war years up to 1944. Of these cases, blindness was bilateral in 119 and unilateral in 640. For practical purposes, blindness was considered as corresponding to uncorrected vision of 20/200 or less, or a permanent narrowing of the visual field of 15 degrees or less. Of the bilateral cases, blindness was due to wounds received in combat in 72, to accidental wounds in 12 and to disease in 35. Of the unilateral cases, blindness was due to combat wounds in 322, to accidents in 143 and to disease in 126. The author pointed out the seriousness of intraocular foreign bodies in military ophthalmology and reviewed the methods of handling them. In 50 per cent of the cases of intraocular foreign body enucleation was necessary.

**Prevention of Blindness** PROF A VÁZQUEZ BARRIERE, Montevideo, Uruguay

Professor Vázquez Barriere pointed out that "blindness is a social calamity" and that it is preventable in 70 per cent of cases. He expressed the belief that the state, through legal enforcement of prophylactic measures and dispersion of educational material concerning preventive measures, should take a more active part in the conservation of vision of its populace. It was proposed that the Pan-American Congress suggest to all the governments of the Americas the advantage of having assembled in a "Sanitary Digest for Prevention of Blindness" all the hygienic precepts and prophylactic measures necessary for such a program. The author outlined in detail the measures necessary for the prevention of blindness resulting from heredity, infections, trauma, intoxications, lack of medical attendance and visual work effected under defective conditions.

**Basic Work in Establishment of a "Code for Illumination."** DR SALVADOR MASSON, Montevideo, Uruguay

The author directed attention to the research being done by investigators and scientific institutions to provide correct illumination for schools, office buildings and industrial establishments. Since many defects of vision begin during the student days, it was suggested that more emphasis be placed on the teaching of "prophylaxis of defective eyesight" to students in elementary schools.

**Statistics in the Prevention of Blindness** PROF BAUDILIO COURTIS, Buenos Aires, Argentina

This paper was not available for abstracting.

CAMPAIGN AGAINST TRACHOMA IN THE AMERICAS

**Report of the Committee on Trachoma of the Pan-American Congress of Ophthalmology** PROF DR IVO CORRÊA MEYER, Porto Alegre, Brazil

Attention was called to the magnitude of the problem in collecting data on the incidence and distribution of trachoma in the Americas. Through the diligence of members of this committee, data on the United States and Canada were assembled by Dr Phillips Thygeson, on Central America, by Dr P Richards, on Argentina, Uruguay, Bolivia, Chile and Paraguay, by Dr J A Sená, on Peru, Ecuador, Colombia and Venezuela, by Dr J Valdeavallano, and on Brazil, by Dr Silvio de Almeida Toledo. The number of cases of trachoma in the Americas was estimated to be 1,000,000. The "trachomatous nuclei" of the United States, Brazil and Argentina were most important. Smaller nuclei were found in Chile, Mexico, Cuba and Paraguay. In such countries as Uruguay, Bolivia and Peru trachoma was of little importance. In many others, such as Guatemala and Costa Rica, trachoma was unknown.

In Canada most of the cases of trachoma were observed in the southern and western provinces. Although no state in the United States was completely free of trachoma, 70 per cent of the cases seemed localized to Virginia, Kentucky, Tennessee, Illinois and Missouri. A minimum of 25,000 cases among the North American Indians was estimated.

In Brazil the disease was chiefly localized in three areas, namely, the northeastern section, the state of São Paulo and the colonial region of the state of Rio Grande do Sul. Until 1943, when the federal government launched a campaign against trachoma, eradication of the disease was in the hands of the state governments.

In Argentina trachoma was endemic in the northern population, but the capital, Buenos Aires, was considered entirely free. The Argentine government was taking steps to eradicate the disease, especially among school children.

The committee proposed that investigations be carried out in the various countries on the prophylactic value of the new chemotherapeutic products, particularly the sulfonamide compounds.

#### **Etiology of Trachoma** DR PHILLIPS THYGESON, New York

The author said that trachoma was caused by a virus of large particle size, belonging to the psittacosis-lymphogranuloma venereum group. The virus appears to be strictly epitheliotropic, and no proof has yet been offered that it occurs in human cells other than the conjunctival and corneal epithelium. Research on this virus is handicapped by the difficulties of culture on living tissues, the absence of a suitable laboratory animal and the difficulty of obtaining material with an adequate concentration of the virus.

#### **Recent Acquisitions in Therapy of Trachoma** DR JOSÉ A. SENÁ, Buenos Aires, Argentina

The chronic evolution, the varied clinical aspects and the latent periods characteristic of trachoma make it difficult to assess a cure. However, it now seems indisputable that the sulfonamide compounds have a beneficial effect on the disease.

#### **Trachoma in Guatemala** DR R. PACHECO LUNA, Guatemala, Guatemala

The author pointed out that trachoma is not observed among the natives of Guatemala. He stressed the fact that trachoma among the foreign population is not transmissible to native wives, half-breed children or Indian servants. Although every condition favorable for the propagation of trachoma is present, the apparent racial immunity prevents this disease from becoming a problem.

#### **Trachoma: Triple Application of Sulfanilamide** DR J. LIJO PAVÍA and DR R. LACHMAN, Buenos Aires, Argentina

The authors reported 4 cases in which sulfanilamide was administered by mouth, instilled locally in solutions of 10 per cent and 25 per cent strength and applied locally as a fine powder. Biopsies of the affected conjunctiva before and after treatment revealed the beneficial effects of this method of therapy.

#### **Trachoma in Pernambuco, Brazil** PROF. FRANCISCO FIGUERÊDO and DR. ALTINO VENTURA, Pernambuco, Brazil

Of the 15,200 patients treated at the clinic and hospital in Pernambuco, approximately 16.50 per cent had trachoma. The authors formu-

lated a plan for the treatment and prevention of trachoma. This plan, from the north of Brazil, was the first to be submitted in the campaign against trachoma.

**Organization of Campaign Against Trachoma in the State of São Paulo (Brazil)** DR SILVIO DE ALMEIDA TOLEDO, São Paulo, Brazil

Dr Silvio de Almeida Toledo, director of the trachoma service of the Department of Health of the State of São Paulo, described his organization of services for the prophylaxis of trachoma throughout the territory during the period of 1943 to 1945 (January to June) and gave a statistical analysis of 435,818 cases of the disease enrolled in the trachoma dispensary units.

The author discussed in detail: (a) medical and sanitary assistance, with respect to attendance, recoveries, operations and laboratory tests, (b) epidemiology, with respect to types of trachoma and nationality, color, sex and profession of patients, (c) trachoma and blindness, (d) trachoma and biologic tests, (e) trachoma and climatic and geographic conditions, and (f) trachoma and contagion, ending with a study of statistics on prevalence and infection.

CONTACT LENSES

**Plastic Contact Lenses** PROF DR BAUDILIO COURTIS, Buenos Aires, Argentina

The author stated "that every eye for which a contact lens is indicated can tolerate such a lens" provided the proper adjustments have been made. Molding the plastic material to the eyeball is unnecessary with use of the trial box of thirty lenses which the author recommended. The prescription of a contact lens begins with measurement of the corneal radius with the ophthalmometer. The corneal diameter and the scleral radius are next measured. Examination of the contact lens in position with a 2 per cent solution of fluorescein sodium and cobalt light is necessary to correct any maladjustments. A final mold of the finished lens should be made in case it is necessary to reproduce it for any reason.

**Stereophotographic Measurement of the Anterior Segment of the Eye** DR ENRIQUE V BERTOTTO, Rosario, Argentina

The author reported on the progress being made in photography of the curvatures of the anterior segment. The accurate photographic measurement of the corneal and conjunctival curvatures makes it possible to produce a contact lens with a larger base resting on the conjunctiva. Additional advantages of this method are as follows: Compression on the eye is avoided, the eye is not touched, and the height of the cornea is more accurately determined. After the eye is anesthetized, the conjunctiva is dusted with powdered charcoal to make this tissue visible on the photographic plate. The photographic measurement is based on the principle that each point of space is fixed on two photographic plates. Once the distance between the objectives, the distance between the objectives and the plates and the distance from the center of the plates to the image are known, the exact position of any point on the anterior segment of the globe can be obtained through a proportional equation.

### Present Day Plastic Contact Lenses DR EDUARDO AMORETTI, Córdoba, Argentina

The author stated that the use of plastic contact lenses is the best method for the exact correction of most errors of refraction. Plastic contact lenses of spherical revolution and toric lenses can be used with success in certain cases. Further work should be done in regard to the appropriate solutions to be used with the current lens. The author appealed for further investigation on the cause of keratoconus.

### GONIOSCOPY

#### Gonioscopy and Goniometry Their Applications and Limitations DR H. SALL SUGAR, Detroit

The author presented a short description of the technic of gonioscopy and stressed the anatomic points to be observed with this method of examination. The trabecular band extending from the termination of Descemet's membrane to the anterior edge of the ciliary body is important from the functional standpoint. Schlemm's canal is not usually visible. The optical illusions created by the distortion of the globe by the contact lens were mentioned. Gradle and Sugar measured the angle of the anterior chamber by calculating the length of an imaginary perpendicular line drawn from the limits of Descemet's membrane to the iris.

Gonioscopy has its practical application in the study of pathologic processes of the limbus and anterior chamber and in the study of glaucoma. The method is an aid in differentiating the congestive attacks of primary glaucoma from the congestive phase of secondary glaucoma. Gonioscopy has shown that in cases of so-called primary glaucoma two clinical signs can be distinguished: the narrow angle and the normal or wide angle.

#### Gonioscopy PROF. DR. JORGE VALDEVELLANO, Lima, Peru

Study of the angle of the anterior chamber was begun by Trantas in 1899 and was pursued by Salzmann and Koeppe. In 1925 Uribe Troncoso invented the gonioscope and used it with the contact lens. Gonioscopy, by permitting a detailed examination of the angle of the anterior chamber, enables one to study one of the factors which contribute to the control of intraocular pressure. From a surgical viewpoint, gonioscopic study helps in determining the appropriate zone for good drainage and may reveal the reason for failure of a filtering operation.

#### New Concepts of Glaucoma Derived from Gonioscopy DR. PETER KRONFELD, Chicago

Gonioscopy has confirmed the mechanism of two well known types of glaucoma: the one due to iris block, and the other to peripheral synechias following retarded formation of the anterior chamber, either postoperative or post-traumatic. With regard to corneoscleral tiephing, gonioscopy has revealed that eyes with wide angles and free from

peripheral synechias are most favorable for this operation, that the most favorable site for the trephination is halfway between the entirely corneal and the mostly scleral position and that the majority of the complications are due to a too rapid decompression. With iridencleisis, an appreciable separation of the internal edges of the wound occurs in 79 per cent of the successful cases and in 62 per cent of the cases of failure. In cyclodialysis a successful operation is assured with a superciliary cleft communicating with the anterior chamber and extending over at least 45 degrees on the dial. Iridectomy is successful only in cases of narrow angle glaucoma and of certain secondary glaucomas.

#### GLAUCOMA

##### **Preglaucomatous State** DR HARRY S. GRADLE, Chicago

In 1924 the author proposed the term "preglaucoma" for the conditions in which ocular hypertension is expected to occur in the course of time. Two types of hypertension can be foreseen: the narrow angle type, with manifestations of acute, uncompensated glaucoma, and the wide angle type, with an insidious beginning. It is important to distinguish between the two types, as provocative tests may prove disastrous in cases of the first type.

In consideration of the eyes in which acute hypertension may develop, the patient's history is of great importance. The patient is rarely under 45 or over 70. Myopia in these patients is rare. The iris which is somewhat thicker and the iris in which dilation of the pupil causes an increased thickness of the base predispose to acute hypertension. In eyes which have had previous prodromal attacks a few traces are usually left, such as slight mydriasis with oval deformation of the pupil or partial atrophy of a sector of the iris.

Greater care is required to discover preglaucoma of a chronic type. The case history furnishes less useful data, and the age range is greater. Gonioscopic examination reveals an open angle with particles of pigment embedded in the trabeculae in some cases. The pupil tends to dilate with a facility unusual in normal eyes. Frequently there is enlargement of the blindspot of from 1 to 5 degrees, for which there is no explanation.

When glaucoma is suspected, provocative tests must be resorted to. These tests are based on the increase in tension stimulated by various well known procedures, the most useful being the drinking test or the use of a weak mydriatic, which produce an increase up to 8 mm.

A 1 per cent solution of pilocarpine nitrate instilled on retiring may be used in the preglaucoma state.

##### **Estimation and Mechanism of the Destructive Effects of Ocular Hypertension** DR AMADEO NATALE, Buenos Aires, Argentina

The various theories of formation of the aqueous humor and the system of drainage of the intraocular liquids were reviewed. The relative parts played by the several anatomic structures both in the production and in the drainage of the intraocular fluids were mentioned. Many observations and experimental data have been accumulated to explain the etiology and physiopathology of glaucoma, but no one has been able to arrive at a theory which is in accord with all the known factors.



## DISCUSSION

DR SILVIO DE ABREU FIALHO, Rio de Janeiro, Brazil Intraocular hypertony is the primary and fundamental cause of the visual decrease in glaucoma, although accessory factors can produce a slower or a more rapid onset of the hypertony. An especially intense compressive action on the nerve fibers at the point where they reach the optic disk is probably the mechanism of the initial destructive effect on vision. If the first effects of compression were felt in the retinal circulation, then the peripheral segments of the retina logically would be the first to feel the effects of increased pressure and this would be reflected in a different type of visual field defect. In some cases nasal depression of the visual field precedes the appearance of the arcuate scotomas.

**Indications for Surgical Intervention in Cases of Glaucoma. How Long Should Medical Treatment Be Continued?** PROR HIRTON ROCHA, Belo Horizonte, Brazil

In cases of chronic simple glaucoma medical treatment needs surgical supplementation from the moment it becomes evident that the disease is progressing in spite of the therapy. Hypertension is only one element in the glaucomatous syndrome, although operation may alleviate the hypertensive state, it should not be entirely separated from the supplementary medical treatment.

Chronic congestive glaucoma, more than the simple type, requires surgical intervention as a weapon against hypertension. In cases of acute glaucoma, if the attack does not yield after twenty-four hours of medical treatment, operation is necessary.

In cases of the so-called inflammatory type of secondary glaucoma, mydriatics should be used, and the response to medical treatment is generally favorable.

In cases of hydrophthalmia early operation is necessary, before physiologic structures are altered.

**Indications for Surgical Treatment of Glaucoma** DR SANTIAGO BARRENECHEA, Santiago, Chile

The author cited cases in which the disease was adequately controlled by medical treatment over a period of years. So long as the hypertension can be regularly controlled there is no need of surgical intervention. If medical treatment fails to control the hypertension, operation should be performed even though the evolution of the disease seems far advanced.

**Indications for Surgical Treatment of Chronic Glaucoma and Choice of Operative Technic** PROR E VELTER, Paris

So long as the symptoms of glaucoma are controlled with miotics and there are no progressive defects in the visual field, surgical intervention may be postponed. The presence of Bjerrum's scotoma is not a contraindication to operation. Even though the fixation point is threatened by progressive narrowing of the visual field, operation should not be deferred, for loss of the central island of vision as the result of operation is rare. The author considers the fistulizing operations the best method in treatment of chronic glaucoma.

**Hemicyclodialysis for Reestablishment of the Physiologic Formation of the Intraocular Fluids** DR ANTONIO TORRES ESTRADA, México, D F, Mexico

The author asserted that the results obtained with cyclodialysis and hemicyclodialysis are superior to the fistulizing operations. The principal effect of hemicyclodialysis is to reestablish drainage of the aqueous through Schlemm's canal.

**Gonioscopy After Lagrange's Operation.** DR JORGE PEYRET, Buenos Aires, Argentina

The author described the usefulness of gonioscopy in the postoperative control of glaucoma after the Lagrange operation.

**Induced Double Retinal Pulse as Observed in Moving Pictures. Sign of Preglaucoma (?).** DR J LIJO PAVÍA, Buenos Aires, Argentina.

Pulsation in the central retinal artery produced with the ophthalmodynamometer and persistence of pulsation in the central retinal vein constitute a double retinal pulse. Cinemas were produced showing this phenomenon. The existence of this sign, in the author's opinion, affords strong presumption that a latent glaucomatous state exists.

**Etiologic Factors of Glaucoma in Colombia.** DR A PESADA and DR J. DÍAZ GUERRERO, Bogotá, Colombia

This paper was not available for abstracting.

**Degenerative Glaucoma.** PROF A TERRES ESTRADA, México D F, Mexico

This paper was not available for abstracting.

**Plasmotherapy of Glaucoma** DR R RODRÍGUEZ BARRIOS, Montevideo, Uruguay

Basing his work on Duke-Elder's experimental studies, the author gave intravenous injections of plasma to patients with glaucoma and reported the clinical histories of a series of patients treated in this way. In most patients an effective decrease of ocular tension was obtained. Among the patients there are cases of primary glaucoma, both of the wide and of the narrow angle type, chronic or acute, as well as 2 cases of inflammatory glaucoma appearing in the course of iridocyclitis, in which a lowering of tension was obtained. In most patients the effect on tension appeared two or three hours after the plasma had been injected and continued for two or three days. In a case of chronic congestive glaucoma with acute onset of hypertension, all other therapeutic measures were useless, but tension was lowered to normal with the use of plasma and remained so for some time. Plasma has not been used in more cases of ocular hypertension because of the difficulty in obtaining it, and only 1 patient received injections of concentrated plasma. In some cases the value of the plasma proteins was studied. The possibility of obtaining an increase in the value of the plasma proteins with appropriate diets was suggested.

## STRABISMUS

**Surgical Treatment of Exophoria and Exotropia** DR GEORGE P. GUIBOR, Chicago

The author presented the conclusions derived from his study of a series of cases of exophoria and exotropia resulting from defects or lesions in the medial longitudinal fasciculus (intranuclear paresis). These cases were characterized by exaggeration of the defect under conditions of fatigue, weakness of one or both medial rectus muscles, a normal near point of convergence for near range and an error of refraction which had no direct relation to the degree of the deviation. Resection of both medial rectus muscles associated with recession of one or both lateral rectus muscles gave better cosmetic and functional results than a similar operation performed in two sessions. Advancement of both medial rectus muscles and recession of a lateral rectus muscle did not produce a permanent cure of the strabismus. Advancement of both medial rectus muscles improved the divergence, but there was a recurrence.

**Surgical Treatment of Concomitant Strabismus** DR THOMAS ALLEN, Chicago

The author emphasized the necessity of a careful preoperative examination. He called attention to the importance of determining the presence or absence of anomalous retinal correspondence. In cases of convergent strabismus with secondary overaction of an inferior oblique muscle recession of the inferior oblique as a supplement to the operation on the rectus muscles was suggested. He stated the opinion that extensive retrocession was more effective in correction of strabismus than complete tenotomy. He described a technic for insertional partial tenotomy, in which the tendon, but not the ligaments, were sectioned.

**Surgical Treatment of Strabismus** DR RENE CONTARDO, Santiago, Chile

The technic employed in the surgical correction of 60 cases of strabismus was described. The author utilized only one thread in suturing the tendon to its new point of insertion. He expressed the belief that this method not only permitted more rapid execution of the operation but added to the certainty of correction.

**Operative Technic for Concomitant Strabismus** DR EDMUNDO SEMERARO, Barbacena, Minas Geraes, Brazil

In the procedure of retrocession, a large portion of Tenon's capsule is displaced backward, along with the muscle tendon, to the new insertion. In the advancement procedure on the opposite side triangular flaps of capsule are resected up to the limbus. The muscle tendon is then reattached to the sclera 3 mm. from the limbus.

**Orthofusor, Amblyoscope and Prisms Indispensable in Treatment of Strabismus** DR J. LIJO PAVIA, Buenos Aires, Argentina

The author emphasized the role of orthopedic training in the treatment of strabismus. He described the orthofusor and the amblyoscope.

and explained their function. Fourteen cases of strabismus were presented in which orthoptic training effected a correction. In some of these cases correction was obtained in four months whereas in the more difficult cases of strabismus correction was not obtained unless orthoptic exercises were given over a two to three year period.

## RESEARCH PAPERS

**Filamentous Keratitis** PROF CARLOS WESKAMP, Rosario, Argentina

This paper was not available for abstracting

**Recent Additions to Knowledge of Experimental Nephrogenous Arterial Hypertension and Ocular Lesions** DR FREDERICO F K CRAMER and DR MIGUEL ANGEL ETCHEVERRY, Buenos Aires, Argentina

Using Goldblatt's procedure (closure of the renal artery with forceps) the authors produced arterial hypertension in dogs and rats. They concluded that the mechanical effect of the elevated arterial pressure was chiefly responsible for the disturbances that they noted ophthalmoscopically. The prolonged action of the experimental nephrogenous increase in tension in these animals caused ocular disturbances of a vascular origin, such as distinct degrees of vascular sclerosis, hemorrhages and exudates, with impairment of renal function of variable degrees and lesions of renal sclerosis.

**Nonvisual Functions of the Retina** PROF CLEMENTE ESTABLE, Montevideo, Uruguay

A critical survey was made of the retinohypothalamic connections and of the centers and tracts through which the retinoadrenal, retinocutaneous, retinogonadal, retinopostural and retinokinetic reflexes are produced. The author described the experiments and microscopic studies which were carried out.

**Images of Secretory Elaboration of the Ciliary Epithelium** DR J SVERDLICK, Buenos Aires, Argentina

With the aid of the staining method of Achucarro and del Rio Hortega, the author was able to demonstrate a granular content at the distal pole of the clear cells in the superficial stratum of the ciliary processes. It was felt that these granules play a definite secretory role in elaboration of certain organic components of the aqueous humor.

**Chronaxia of the Extraocular Muscles** DR WASHINGTON ISOLA, Montevideo, Uruguay

Chronaximetric investigations were carried out on the extraocular muscles of dogs and rabbits. The author found that different chronaxias existed for the different muscles. For certain muscles double or triple chronaxias existed. On the basis of this work the extraocular muscles were classified as flexor and extensor.

**Circulatory Mechanism of the Iris** PROF CLEMENTE ESTABLE and  
PROF R RODRÍGUEZ BARRIOS, Montevideo, Uruguay

The circulatory mechanism of the iris was studied microscopically and in vivo in albino animals. The authors concluded that vasodilatation tends to produce miosis, and vice versa, and that vasoconstriction facilitates mydriasis, and vice versa. The slightest oscillation of the intraocular pressure influenced the circulation of blood in the iris. Subconjunctival injections of any solution produced mechanical effects on the circulation of blood in iris tissue independent of the action of the solution. The circulatory disturbance produced by nipectomy, paracentesis, prolapse of the iris and numerous drugs were studied.

**Adrenergic Innervation of the Smooth Musculature of the Lower Eyelid** DR Z M BACQ and DR WASHINGTON ISOLA, Montevideo, Uruguay

The contraction of smooth palpebral muscles was studied in dogs and cats. In this work new proofs of the theory of chemical transmission of nerve impulses were offered. On the basis of this theory, the behavior of smooth muscle in the eyelids in certain clinical syndromes accompanied with an increase in sympathetic tone was explained.

**Interpretation of Kolmer's Rods in the Nerve Cells of the Retina**  
DR J SVERDLICK, Buenos Aires, Argentina

By application of special stains the author studied Kolmer's rods in the human retina. He found these rods to be present in almost all the cells of the internal granular layer.

UNOFFICIAL PAPERS

**Ocular Tuberculosis and Tuberculin Therapy. Part of a Clinical Investigation (1927-1945)** PROF CARLOS CIARLIN, Santiago, Chile

The author called attention to the frequent occurrence of idiopathic ocular disorders in tuberculin-sensitive persons with an antecedent history of tuberculosis in the family. A comprehensive review of the literature on this subject was made. He called attention to the success of tuberculin therapy for these ocular disorders, as employed by him and by other investigators.

**Pathologic and Therapeutic Aspects of Retinal Detachment** DR H ARRUGA, Barcelona, Spain

A review of the pathologic and therapeutic aspects of retinal detachment was presented. According to the author, the fundamental concepts of retinal detachment as proposed by Gonin have been modified very little through a period of years. From an etiologic standpoint, the retina probably does not become detached unless it is diseased. Trauma of the eye as a factor in detachment probably does not have as much importance as was at first thought. Excessive stooping, sneezing and coughing are probably important factors in producing detachments in myopic persons and in patients recovering from cataract operations. The author stated the belief that a healthy choroid is the chief factor in the

cure of detachment and, for that reason, advised minimal operative trauma to this tissue. He recommended adequate rest in bed both before and after operation. He utilizes injection of air into the vitreous as a means of maintaining tension within the eye after the surgical procedure.

### Venous Thrombosis and Recurrent Vitreous Hemorrhages, PROF. E. VELTER and PROF. A. G. RENARD, Paris

The authors pointed out that newly formed venous collaterals, after partial venous thrombosis, are very fragile. Bleeding from these newly formed venules is probably responsible for the recurrent hemorrhages observed in the retina and vitreous after periphlebitis. According to the authors, in most cases of periphlebitis of the retinal veins in young persons the condition is progressive and is nearly always due to tuberculosis. The various therapies advocated for this disease have been unsatisfactory.

### The Accommodative Unit in Corrected Ametropias, DR. JOSEPH I. PASCAL, New York

A person whose ametropia is corrected by lenses is said to have "lens emmetropia," although his condition is somewhat different from that of a person with natural emmetropia. The accommodation of the subject with natural emmetropia corresponds exactly to the dioptric power of the distances of fixation, and the accommodation of the subject with corrected ametropia also corresponds to the dioptric value of the distances, although expressed in terms of its own basic unit of accommodation.

Each person with corrected ametropia has his own accommodative unit, the value of which depends on the class and degree of his ametropia and on the distance of the corrective lens from the eye. The accommodative unit of the person with natural emmetropia is 1 D, that of a subject with corrected hypermetropia is always more than 1 D, and that of a subject with corrected myopia is less than 1 D. For example, a subject with 5 D of hypermetropia with his correcting lens at a distance of 15 mm from his eye would have an accommodative unit of 1.17 D. A subject with 5 D of myopia with his corrective lens at the same distance would have an accommodative unit of 0.865 D. In order to focus at 0.25 meter, each subject would have to use 4 units of accommodation, which represents 4.68 D for the hypermetropic subject and 3.46 D for the myopic subject.

The standard formula for the accommodative unit is

$$U = \frac{1}{(1 - dL)} \quad (1)$$

which can be simplified as follows

$$U = 1 - 2 \, dL \quad (2)$$

The increase in the accommodative unit for the various refractions shows an interesting curve, in the shape of a parabola, with a sharp and rapid ascent for corrected hypermetropia and a slow and gradual descent for myopia.

*The Replacement Lens and the Accommodative Unit*—All or part of the accommodation can be replaced by a positive lens. The degree of this lens can be calculated in exactly the same way for the subject with natural emmetropia as for the subject with "lens emmetropia," so long as the accommodation can be calculated in corresponding accommodative units. The formula for the replacement lens is

$$L' = \frac{A}{LdA} \quad (3)$$

in which  $A$  is accommodation, expressed in accommodative units. When this is expressed in diopters, the formula for the replacement lens is as follows

$$L' = \frac{A}{UdA} \quad (4)$$

The degree of the replacement lens depends not only on the class and degree of the ametropia and the position of the corrective lens but also on the stage of the accommodative process in which the diopter or the accommodative unit should be replaced. For example, a stronger lens is needed to replace the second unit of accommodation than that necessary for the first, and lenses of higher degrees, for the third, fourth and fifth units of accommodation, and so on. The graph for replacement lenses is in the form of a section of a parabola, showing the increasing degrees for the different stages of the process.

The replacement lens, therefore, has an efficiency related to the accommodation, which depends on whether the lens is equal, greater or smaller than the accommodation it replaces. In cases of natural emmetropia and corrected myopia the replacement lens has a negative efficiency, because it has a greater dioptric power than the accommodation it replaces. In cases of corrected hypermetropia the replacement lens has a positive efficiency inasmuch as it replaces that part of the accommodation which should be used to neutralize the hypermetropia totally or partially, its efficiency is negative when it replaces accommodation above this level.

This concept of the accommodative unit clearly explains why, from the optical standpoint, the subject with corrected hypermetropia becomes presbyopic earlier than the subject with corrected myopia, it also explains why in cases of anisometropia, because of the different accommodative units for the two eyes, it is wisest to prescribe a stronger lens for reading for the eye with the least intrinsic power of refraction, and why in cases of astigmatism although properly corrected a perfect focus for near vision cannot be obtained, owing to the different accommodative unit for each meridian.

#### History of Ophthalmology in Latin America DR MOACYR E ALVARO, São Paulo, Brazil

The author traced the origin and trends of ophthalmology in the various Latin American countries. Most of the chairs of ophthalmology in the South American countries were established in the period from 1875 to 1890 by European-trained ophthalmologists. In more recent years, the European influence on ophthalmologic thought has been less noticeable in South American countries because students have

remained at home for postgraduate study In Mexico, Cuba and the Central American countries most of the younger ophthalmologists are American trained

**Damel's Technic for Correction of Generally Contracted Orbital Socket** PROF R LAJE WESKAMP, Córdoba, Argentina

Damel's operation for restoration of the conjunctival cul-de-sac is destined for cases in which the loss of the inferior fornix makes the cavity incapable of retaining an artificial eye A horizontal incision is made parallel to and 6 mm from the inferior lid border The conjunctiva is undermined backward and is freed from all adhesions A new cul-de-sac is then made by stitching the mobile conjunctiva to the deep surface of the skin near the orbital floor

**Extraction of Foreign Bodies with Aid of the Slit Lamp** DR A POSADA, Bogotá, Colombia

This paper was not available for abstracting

**A New Operative Technic of Conjunctival Grafting in the Pterygium.** DR ROQUE BELLIDO TAGLE, Lima, Peru

The apex of the pterygium is peeled from the cornea in the usual manner, but the body of the pterygium is resected leaving a semilunar defect extending from the limbus to the caruncle The defect is covered by a graft obtained from the conjunctival tissue along the superior limbus and anchored with suitable sutures The donor area is closed with a running stitch

**Onchocerciasis in Guatemala** DR E PACHECO LUNA, Guatemala, Guatemala

Onchocerciasis is endemic in certain limited areas of Guatemala and is responsible for a high percentage of blindness among persons working on coffee plantations A species of fly is the intermediate host, and the disease is transmitted from one human host to another by the bite of this fly The filariae have a predilection for the subcutaneous tissue of the head and form fibrous tumors as they reproduce The microfilariae may infect any of the tissues of the eye With repeated infections of the eye chronic keratitis or progressive uveitis develops, ultimately leading to phthisis bulbi Except for excision of the fibrous tumors, there has been no satisfactory treatment

**Intracapsular Cataract Operations** DR MANUEL ANTON PEREZ, Habana, Cuba

A series of 250 intracapsular cataract extractions was reviewed The author extracted the cataracts with a Sinclair forceps and Arruga hook In all but 10 cases some type of iridectomy was performed The corneal incision was made with the Graefe knife, and Liegard's corneoscleral suture was inserted

**Ocular Alterations Associated with Leprosy** DR SIQUEIRA DE CARVALHO, Rio de Janeiro, Brazil

This paper was not available for abstracting



**Actual Conditions in the Onchocerciasis Clinic** DR M PUIG SOLANES,  
México, D F, Mexico

This paper was not available for abstracting

**Alterations in Detached Retina as Observed by Stereoscopic Ophthalmoscopy** PROF ARCHIMEDE BUSACCA, São Paulo, Brazil

Stereoscopic ophthalmoscopy facilitates the diagnosis of minute retinal detachments because it is possible to visualize the separation of the retina from the underlying pigment epithelium. The changes noted with detachments at the fovea and the perifoveal region were described.

**Pseudotumoral Exophthalmos** PROF E VILTLER and DR GUY OFFRET  
Paris

The authors called attention to cases of progressive exophthalmos, either unilateral or bilateral, in which surgical exploration failed to demonstrate the presence of an intraorbital tumor. Histologic examination in these cases revealed a true increase in the volume of the extraocular muscles. The role of the endocrine glands, particularly the thyroid, and the possibility of intraorbital phlebitis as etiologic agents in this type of exophthalmos were discussed.

**Keratoconus in Colombia** DR J DIAZ GUERRERO Bogota, Colombia

This paper was not available for abstracting

**Microphakia Associated with Secondary Glaucoma** DR J MARTINS  
ROCHA, Campinas, Brazil

This paper was not available for abstracting

**Relation of Avitaminosis A to Infantile Blindness** DR J TAVARES,  
Rio de Janeiro, Brazil

This paper was not available for abstracting

**Visualization of the Choroidal Vessels with del Río-Hortega's Silver Impregnation** DR J SVERDLICK, Buenos Aires, Argentina

The vascular network of the human choroid was studied with the silver impregnation stain of del Río-Hortega. Anastomosis of the venous channels was described.

**Difficulties in Clinical Interpretation of Syndromes of Compression of the Intracranial Portion of the Optic Nerve** PROF E VELTER and DR DESVIGNES, Paris

The authors mentioned numerous clinical conditions that can, directly or indirectly, produce compression on the intracranial portion of the optic nerve. They emphasized that a careful neurologic examination must be made and careful attention directed to the clinical evolution of the signs and symptoms if mistakes in diagnosis were to be avoided.

**Cataract Operation with a Security Knot** DR A POSADA and DR J. DÍAZ GUERRERO, Bogota, Colombia

This paper was not available for abstracting

**Relation of Ocular Tension, Arterial Tension, Venous Pressure and Rate of Circulation** DR M PUIG SOLANES, México, D F, Mexico

This paper was not available for abstracting

**Local Use of Penicillin in Ophthalmology** DR E SALERNO, São Paulo, Brazil

The author cited 2 cases of intraocular infection and 1 case of external infection in which penicillin had been successfully employed. For intramuscular use, a dose of 10 000 units given every three hours day and night was recommended.

## Book Reviews

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*Les yeux et la vision des verébrés* By A. Rochon-Duvigneaud  
Pp 719, with 500 illustrations Paris Masson & Cie, 1943

It is not often that a man has the privilege, by living long enough, of seeing his dreams come true. Rochon-Duvigneaud, now in his middle eighties, but in no way less alert than when I first knew him, over a quarter of a century ago, seems to have had this luck. He was one of the most prominent French ophthalmologists by profession, but he strikes one as having always been a zoologist and a student of comparative anatomy by taste. He retired from active duty in the Laennec Hospital, Paris, in 1926 and has spent the last fifteen years in collecting his previous papers, completing his studies of animal eyes and writing this remarkable book on the eyes and vision of the vertebrates.

Chapter 1, which contains 150 pages, gives a description of the human eye, with constant reference to similar structures in animals. Chapter 2 (30 pages) deals with the origin of the vertebrate eye. Notwithstanding well developed eyes in a few invertebrates such as the gastropods and cephalopods, with a retina, a lens, a transparent cornea and a pigmented diaphragm, the author does not believe that the vertebrate eye can in any way have been derived from the invertebrate eye. Studies in comparative embryology show that at an early stage there is a striking similarity in the eyes of the embryos of all classes of vertebrates. Differentiation comes later.

Succeeding chapters are devoted to the description of the eyes of fishes (cyclostomes, selacians, teleosts, chondrosteans and dipnoans), batrachians, reptiles, birds and mammals. It is, of course, impossible to review this book in detail, and I can note only some of the most striking features mentioned. I have, of course, read this book as an ophthalmologist, not as a zoologist, and it was chiefly with reference to the physiology and pathology of the human eye that my interest was awakened.

*Fishes*—It is usually accepted that refraction is hyperopic in selacians and myopic in teleosts, but the author finds hyperopic refraction even in the latter. There is a curious description of *Anableps tetraphthalmus*, with its bifocal cornea. There are two pupils in each eye, and, as this fish usually has its head half out of the water, the one is used to see through air and the other to see through water. *Syngnathus acus* has a pigmented layer in the cornea, the center remains clear, and this may constitute a diaphragm useful in improving vision. Ocular tension in fishes is low. There is no evidence of filtration in the angle, no canal of Schlemm.

*Batrachians*—The author finds a muscular diaphragm in all arterioles supplying the uvea, particularly in the anterior segment, and he believes that this may regulate the ocular tension. There is a curious atrophic eye in *Proteus anguinus*. A perfectly normal embryonic eye forms in the larva, then it shrinks, and in the adult it is but a small pigmented

nodule, some 300 microns in diameter, hidden under the skin. *Proteus anguinus* lives in subterranean waters, away from any light. Has this anything to do with this atrophy?

*Reptiles*—In the turtle, accommodation is due to the formation of an anterior lenticonus through contraction of the iris. The retina is particularly well developed in the saurian eye. Amacrine and ganglion cells are probably better represented here than in any other animals. One of the most curious features in reptiles is the fact that many of them see through a fixed and transparent lid (ophidians).

*Birds*—The author has always been particularly interested in birds, and the chapter on the physiology of their vision is well worth reading. He does not believe, as many have suggested, that birds have a visual acuity much better than man's. The colored drops in the bird retina are, of course, discussed, but their true use remains unknown. The author has studied the visual field by placing the head in the center of a perimeter, baring the posterior aspect of the sclera and moving along the arc of the perimeter a small light, which is seen on the sclera. In that fashion he has studied the overlapping of the binocular field and the visual axes. This work is very interesting, as some birds of prey have a double fovea. One is central, looks laterally and is used for monocular vision, the other is peripheral, looks forward and is used for binocular vision. The eyes of most birds are aspherical, the upper half, which sees the ground as the bird is in flight, is larger than the lower half. The author points out that the horned owl has a very large canal of Schlemm (2 mm in diameter) and that some problems of physiology concerned with ocular tension might be solved by using this animal for experimental research.

*Mammals*—It is only with mammals that the movements of the two eyes are associated. In more primitive forms they are independent. Sometimes this is very evident (chameleon) because the amplitude of the independent movements is great. Another characteristic feature of the mammalian eye is that blood vessels penetrate the retina. There is a detailed description of the mole's eye, which is curiously undeveloped. With the simians, one nears man, and many human features are already evident: small cornea, well developed fovea, strong ciliary muscle, fairly parallel visual axes and convergence.

This review can give but an incomplete idea of this excellent book. There are many references at the end of each chapter, and the illustrations are superb. Although the book came out in 1943, the publishers were able to print it on perfect paper, which they had had in stock since before the war. This is fortunate, for the book would have lost a great part of its value if the 500 illustrations had come out less well.

EDWARD HARTMANN, M.D.

**Fundamentals of Clinical Neurology.** By H. Houston Merritt, M.D., Fred A. Mettler, M.D., and Tracy Jackson Putnam, M.D. Price, \$6. Pp. 289, with 96 illustrations. Philadelphia: The Blakiston Company, 1947.

In a small volume of 289 pages, and 96 illustrations, the reader will find an excellent introduction to clinical neurology. The subject is presented in an original manner and is discussed in two main

divisions examination of the nervous system and the anatomic diagnosis The first part consists of a practical description of the examination of the patient, and the second, an explanation of the anatomy and the fundamental physiology of each part A brief description of the commonly encountered disorders is added The illustrations are taken mostly from Mettler's excellent "Neuroanatomy", they are well chosen and are a considerable help to the text While treatment is only briefly discussed, there is an excellent chapter on the examination of the spinal fluid with an interpretation of the findings

This is a thoroughly practical work which should be of great service to the general practitioner and to the ophthalmologist, who so frequently encounters neurologic problems

ARNOLD KNAPP

### **An Introduction to the Prescribing and Fitting of Contact Lenses**

By Frank Dickinson and K G Clifford Hall Price, £2 2s  
Pp 168, with 10 colored photographs, 55 halftone photographs  
and 32 diagrams London Hammond, Hammond & Company,  
Ltd, 1946

Several books on contact lenses have appeared in this country Of these, the most comprehensive was that by Obrig, which has already been reviewed in the ARCHIVES (28 568 [Sept ] 1942) The authors of the book under review, which is the first of its kind to be printed in England, have been much influenced by Obrig's work and generously acknowledge the obligation

All known methods of fitting contact glasses are carefully described, but the authors prefer the technic of the molded lens For taking the impression they used "negocoll" at first, but now prefer "moldite" (made in the United States) or "zelex," a British preparation A positive cast of dental stone is then made and sent to the lens makers, who return semifitted plastic shells These are then modified to fit accurately

In considering the problem of contact glasses as a whole, the authors are objective and honest They point out that "there remains an inescapable limitation to the sphere of usefulness of contact lenses," and they warn that "all-day tolerance is rather an exceptional performance" Their recognition that among the motives actuating patients to present themselves for contact glasses "the vanity motive is perhaps the most powerful of all" is shrewd, and should be salutary "In a sense," they say, "contact glasses are complementary to spectacles They may be regarded simply as an alternative means for the correction of refractive errors

Cases are occasionally encountered in which the non-medical practitioner would hesitate to proceed except under the guidance of an experienced ophthalmic surgeon Problems impinging on ophthalmology may properly be handled only by the ophthalmologist"

The photographs in this work are the best examples I have ever seen of the pictorial description of technic and should be studied and imitated by medical photographers in all fields They may account for the high price of the book—more than \$8 at the current rate of exchange

G M BRUCE

# ARCHIVES OF OPHTHALMOLOGY

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## BETA IRRADIATION IN OPHTHALMOLOGY

CHARLES E ILIFF, M D

BALTIMORE

THE MAJORITY of reports on radiation therapy of the eyes are concerned with gamma rays. The purpose of this paper, however, is to discuss the use of the less well known beta rays in the treatment of nonmalignant lesions of the lids and the anterior ocular segment.

Beta rays possess the same qualities as other rays in the power of selective tissue destruction, but, in contrast to gamma rays,<sup>1</sup> they penetrate about 3 mm of tissue only. This makes them ideally suited to treatment of the anterior ocular segment. In no single case in which this therapy has been used has any damage to the lens been observed. This has been true clinically, as well as in animal experiments, in which in 1 instance a rabbit cornea was given 300 gram seconds of beta rays without a resultant cataract.<sup>1</sup>

The ease of application is a great advantage in the use of the beta rays. In the removal of certain small benign tumors of the lids or the conjunctiva, the absence of pain, the fact that hospitalization is not required and the excellent cosmetic result all make beta radiation therapy peculiarly acceptable both to children and to adults, especially persons who object to surgical procedures. In the treatment of tuberculosis of the anterior ocular segment a certain analgesic effect has been noted and the course of the disease seems to be shortened. The symptoms of vernal conjunctivitis are decreased and the follicles disappear with treatment. Superficial vessels of the cornea can be occluded and new vascularization inhibited, thus, beta irradiation is ideal as postoperative therapy in cases of lamellar keratectomy, in preventing postoperative granulation and in inhibiting the overgrowth of connective tissue.

### TREATMENT

Beta radiation is applied with a special radon applicator (fig 1) designed by Mr Curtis F Burnam.<sup>2</sup> This consists of a 5 mm soda glass bulb containing from

From the Wilmer Ophthalmological Institute of the Johns Hopkins Hospital and University.

1 Hughes, W F, and Iliff, C E. The Effects of Beta Irradiation on the Rabbit Eye, *Am J Roentgenol* **56** 502 (Oct) 1946.

2 Burnam, C F, and Neill, W, Jr. Use of Beta Ray of Radium Applicator. Description of Method and Results Obtained in Superficial Lesions of Eye, *South M J* **33** 279, 1940.

200 to 500 millicuries of radon, enclosed in a brass cylinder with walls 2 mm thick. From a 4 mm window at one end of the applicator, beta and gamma rays pass unfiltered, the alpha rays being stopped by the soda glass container.

The dose of beta radiation is calculated in gram seconds (the product of the weight of radium in grams, or its equivalent in curies of radon, and the exposure time in seconds). Since the skin erythema dose of unfiltered beta rays is 18 gram seconds, whereas that of gamma rays is 8 gram minutes, it is possible to give adequate beta radiation therapy with such short exposures that the effect of the gamma rays is negligible.

The applicator is placed as close to the lesion as possible (approximately 1 to 3 mm) and moved slowly back and forth across an estimated square centimeter of field, giving a spray action to the rays. The distance of application is important, as the strength of the delivered dose varies inversely with the square of the distance from the source. Care should be taken that the overlapping effect does not exceed the calculated optimum dose. In the treatment of small tumors, pterygiums, granulation tissue or blood vessels invading the cornea, the applicator is held in contact with the lesion.

Beta irradiation has a cumulative effect if repeated doses are given within a period of two weeks. The total dose to any one area should not exceed 18 gram seconds during this period. With adults not more than 12 gram seconds is given to an area at one treatment, with children the dose is started at 3 to 4 gram seconds.

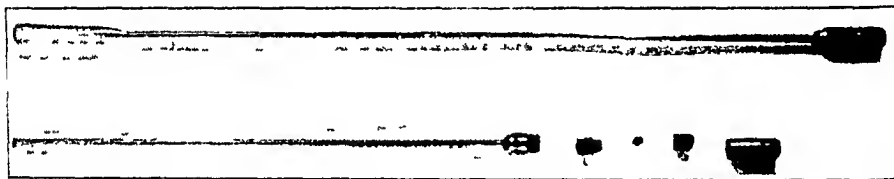


Fig 1—Burnam beta ray applicator (radon)

Before a maximum dose is administered, the individual sensitivity to beta rays should always be tested. The course of treatment consists of 18 gram seconds in a two week period, followed by a rest period of two to three weeks. At the end of this time another course of 18 gram seconds may be given. When the condition is not acute, the patient may be placed on a monthly maintenance dose of 8 to 10 gram seconds.

When contact therapy is used, or when photophobia, pain and lacrimation make adequate exposure impossible, local anesthesia with tetracaine hydrochloride is helpful. The treatments themselves cause no pain, but an exacerbation of the existing symptoms frequently occurs in three to four hours and may last twenty-four hours. In such cases a mild sedative is helpful.

In some instances a punctate stippling of the cornea (clearly visible when stained with fluorescein) has appeared within twenty-four hours and lasted four to five days. Loss of cilia is rare but does occur in heavily treated areas of the lids.

#### VERNAL CONJUNCTIVITIS

Throughout the literature on vernal conjunctivitis there are many reports on the excellent results with radium therapy. However, owing to scarcity of data and to variations in technic, evaluation of this material is difficult. An adequate review of the literature to 1929 was

given by Kumer and von Sallmann,<sup>3</sup> and since that time outstanding reports have been made by Quick,<sup>4</sup> Stallard,<sup>5</sup> Robinson,<sup>6</sup> Bowing and Fricke<sup>7</sup> and Pendergrass and Andrews.<sup>8</sup>

*Material*—Data on 60 patients with vernal conjunctivitis who were treated with beta rays appear in table 1. All the patients were followed for at least one full season of nine months and some for as long as six years. The majority of white patients had exhibited symptoms before the age of 30, the majority of Negro patients, before the age of 10 years.

The total dose producing a cure ranged from 7 gram seconds, in an early lesion, to 258 gram seconds, spread over three and one-half years, in a case of a long-standing palpebral lesion. Most patients (70 per cent) showed decided symptomatic improvement with less than 40 gram seconds of beta radiation given as spray therapy.

A case illustration of the course of the disease and the rate of clearing with therapy is that of W. C., a 5 year old Negro boy, first seen in July 1941. Typical symptoms of lacrimation, photophobia, itching and discharge had been present during the previous season, and at the time of examination the lids had a velvety appearance but no follicles. The limbal vegetations were present around the upper half of each cornea from 3 to 9 o'clock (fig. 2A).

Two treatments, with a total dose of 10 gram seconds, were given to the limbus, and four treatments, with a total dose of 20 gram seconds, to the upper lids. After these treatments he became free from symptoms and the vegetations flattened within three weeks (fig. 2B). The following year there was a slight recurrence of the disease, and 9.4 gram seconds of beta radiation was given to the limbus and 7 gram seconds to the lids. The child had no further symptoms until the summer of 1943, when there was a mild recurrence, with lacrimation and itching. At this time the limbus of the left eye was treated with 9 gram seconds of radiation, and the right eye was used as a control. The left eye promptly cleared, whereas the right eye continued to give symptoms until it also received beta radiation therapy. For purposes of checking, the child was seen in the summer of 1944 and again in the spring of 1945, no recurrence of symptoms or signs was evident on either occasion.

The severest case of limbal vernal conjunctivitis seen in this series was that of C. O., a 7 year old Negro boy (fig. 3A). The disease had been present four years, and vision was reduced to 10/200 in each eye. For three seasons the boy received therapy, the total dose being 80 gram seconds. Improvement was slow, but by the end of the first season there was definite gain, and by the end of the third season his vision had improved to 20/40 (fig. 3B). He is still under treatment at the time of this report.

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3 Kumer, L., and von Sallmann, L. *Die Radiumbehandlung in der Augenheilkunde*, Vienna, Julius Springer, 1929.

4 Quick, D. Radium in Vernal Catarrh, *Arch. Ophth.* **4**: 212 (Aug.) 1930.

5 Stallard, H. B. Effect of Radium Emanations, *Tr. Ophth. Soc. U. Kingdom* **53**: 224, 1933.

6 Robinson, G. A. Benign Lesions of Eye, Ear, Nose and Throat, *Am. J. Roentgenol.* **33**: 801, 1935.

7 Bowing, H. H., and Fricke, R. Radium Treatment of Vernal Conjunctivitis, *Am. J. Roentgenol.* **38**: 740, 1937.

8 Pendergrass, E. P., and Andrews, J. R. The Radium Emanation Treatment of Vernal Catarrh, *Am. J. Roentgenol.* **34**: 637, 1935.



TABLE 1—Data on Patients with Vernal Conjunctivitis

Name	Race, Sex, Age, Yr	Duration Before Treatment	Degree * and Area of Involvement		Total Dose, Gm See †	Time Under Observation	Result
			When First Seen	When Last Seen			
I S	W, M, 19	2½ years	Severe, 4 lids	Slight scarring, 3 lids	258 to upper, 16 to lower lids	6 years	Cure
C W	N, F, 5	Less than 1 yr	Mild, upper lids and limbus	Clear	10 7, lids and limbus	1 year	Cure
W S	W, M, 42	2 years	Moderate, upper lids	Few follicles, upper lids	35	3 seasons	Improvement
M G	W, M, 29	1 year	Moderate all 4 lids	Slight scarring, upper lids	1940 29 (3) 1941 36 (7) 1942 38 (5), 101	4 years	Improvement
L C	W, F, 5	9 months	Moderate, all 4 lids	Still some injection of lids	16 8, lower lid, 12, upper lid	2 seasons	Improvement
I K	N, F, 18	Less than 1 yr	Mild, limbus	Cure	7	3 years	Cure
W O	N, M, 5	Less than 1 yr	Moderate, palpebral and limbal areas	Cure	1911 10 9 to limbus, 20 to lids, 1942 9 4 to limbus, 7 5 to lids 1943 18 to limbus of left eye	1941 1946 5 seasons	Cure
P T	N, F, 3	6 months	Mild, limbal area	Slight limbal eleva- tion	6 5	2 seasons	Improvement
W M	W, M, 27	15 years	Moderate, 4 lids	Still some follicles upper lids	46 4	2½ season	No Improvement
C A	N, M, 24	Unknown	Moderate, 4 lids and limbus	Slight scarring, upper lids	1939 99 to lids, 76 to limbus 1940 19 to lids heavily treated at Kelly ‡ and Wilmer	3 years	Cure
S D	W, M, 42	3 years	Moderate, upper lids	Moderate, injection, upper lids	30 (4)	3 years	No Improvement
P C	W, F, 17	1 year	Mild, upper lids	Slight injection, upper lids		1 season	Improvement
P J	W, F, 32	1 year	Moderate, upper lids	Cure	10 (5)	2 years	Cure
M S	W, M, 20	4 years	Moderate, 1 lid	Slight, 1 lid	32 (4)	1 season	Improvement
P P	W, F, 18	6 weeks	Moderate, 3 lids	Slight, 2 lids	16	1 season	Improvement
R R	W, F, 40	1 year	Moderate, upper lids	Slight, 1 lid	28	2 years	Improvement
W N	W, F, 40	6 years	Moderate, upper lids	Slight, upper lids	28 right eye only	2 seasons	Improvement
M M	W, M, 32	3 years	Moderate, upper lids	Slight, upper lids	18	1 season	Improvement
G H	W, M, 32	2 years	Moderate, upper lids	Slight, upper lids	0	1 season	Improvement
S H	W, M, 16	3 years	Moderate, 4 lids	Slight, upper lids	25	1 season	Improvement
Q O	W, M, 30	2 years	Slight, upper lids	Slight, upper lids	18	1 season	Improvement
T W	W, M, 66	3 years	Slight, upper lids	Cure	18	1 year	Cure
W W	W, M, 4	6 weeks	Slight, limbus	Cure	10	1 year	Cure
L J	N, M, 9	2 years	Moderate, upper lids	Moderate upper lids	10 Left eye 1943 25 right eye 1945 10 left eye 1946 10	3 years	Improvement

U W	N, M, 6	2 years	Moderate, upper lids	Slight, 1 upper	88	2 seasons	Improvement
S B	W, M, 4	3 months	Mild, limb	Cure	14	1 year	Cure
F K	W, M, 8	2 years	Moderate, upper lids	No, upper lids	24	1 season	Improvement
L G	W, F, 18	Several years	Upper lids and limb	No limbal infection but upper lids still moderately affected	1911 70 6 to lids, 1912 56 2 to limb	2 seasons	No improvement
A M	W, M, 12	1 year	Severe, upper lids	Occasional follicle	1912 85 1 to right eye 19 6 to left eye	2 years	Improvement
V G	W, F, 10	3 years	Severe, upper lids	Some scarring, upper lids	Right eye 108, left eye 100	3½ years	Improvement
M G	W, M, 25	2 years	Moderate, upper lids	Mild, upper lids	21 to lids	2 seasons	Improvement
R W	N, F, 10	3 weeks	Mild, upper lids and limb	Cure	139 to lids, 34 to limb	2 years	Cure
H M	W, F, 5	8 months	Mild, upper lids and limb	Cure	26 9 to lids, 15 1 to limb	2 seasons	Cure
M C	N, F, 7	2 years	Mild, upper lids	Cure	27 8	1 season	Improvement
E P	N, M, 10	1 year	Mild, limb	Cure	20 2	2 seasons	Cure
W M	N, F, 6	3 years	Moderate, limb	Eyes white	11 3	1 year	Improvement
L Y	W, M, 15	6 months	Mild, upper lids	Cure	18 4	3 years	Cure
C O	N, M, 9	4 years	Very severe, limb	Moderate, limb	80 to limb, 25 to lids	5 seasons	Improvement
M M	W, M, 14	3 years	Severe, upper lids	Mild, upper lids	89 4 to lids (12)	2 years	Improvement
W C	W, M, 26	4 years	Severe, 4 lids	Cure	37 9 to upper and 11 4 to lower lids, 21 to limb	6 years	Cure
O T	N, M, 3	1 year	Moderate, limb	Cure	23	1 season	Improvement
K O	W, M, 8	1 year	Severe, upper lids	Some scarring	82 (8)	2 years	Improvement
Y W	N, F, 5	3 weeks	Moderate, limb	Slight, limb right eye	17	1 season	Improvement
C S	W, F, 30	Unknown	Moderate, upper lids	Mild, upper lids	9	1 season	Improvement
T J	N, F, 16	1 year	Mild, lids and limb	A few follicles, left upper lid	38 (5) to lids, 11 5 to limb	2 seasons	Improvement
E R	N, M, 4	?	Mild, upper lids	No lesion	5	1 season	Improvement
B B	W, F, 3	1 year	Moderate, 4 lids	Mild, 4 lids	24 (3)	1 season	Improvement
D J	W, F, 9	3 weeks	Moderate, upper lids	No lesion	20	1 season	Improvement
V R	N, F, 4	6 months	Moderate, limb	Mild, limb, right eye	44 (5)	1 season	Improvement
D F	N, M, 2	1 week	Moderate, limb	Mild, limb	9	1 season	Improvement
W S	W, M, 12	1 year	Moderate, 4 lids	Cure	45 (5)	2 seasons	Cure
B H	W, F, 6	1 year	Moderate, 4 lids	Mild, upper lids	24 (2)	1 season	Improvement
J W	W, M, 24	6 months	Moderate, upper lids	Mild, right upper lid	33 (4)	1 season	Improvement
O S	W, F, 29	3 years	Moderate, 4 lids	Mild, 3 lids	50 (4)	1 year	Improvement
J M	W, F, 24	3 years	Moderate		80 (8)	2 seasons	Improvement
M C	W, F, 31	3 years	Slight, upper lids	Cure	50 (4)	2 seasons	Cure
A Z	W, M, 5	1 year	Slight, upper lids	Cure	15 (2)	3 years	Cure
J S	W, M, 42	2 years	Slight, upper lids	Slight, upper lids	45	2 years	Improvement
S	W, M, 25	1 year	Moderate, upper lids	Mild, upper lids	72 (6)	1 season	Improvement

\* Severe involvement indicates the presence of large follicles, profuse discharge and prominent symptoms, moderate, the presence of some follicles, discharge and redness and moderately severe symptoms, mild, the presence of small or absent follicles, redness and/or slight discharge and few or no symptoms  
† Values in parentheses indicate number of treatments  
‡ Howard A. Kelly Hospital

A case of a palpebral lesion is that of M W, a 6 year old Negro boy. The symptoms had been present two years (fig 3 C). He was given nine treatments at intervals of two to three weeks, the total dose equaling 88 gram seconds (fig 3 D). The follicles disappeared, and he became almost free from symptoms. This child if he can be reached, will be given two prophylactic treatments next season.

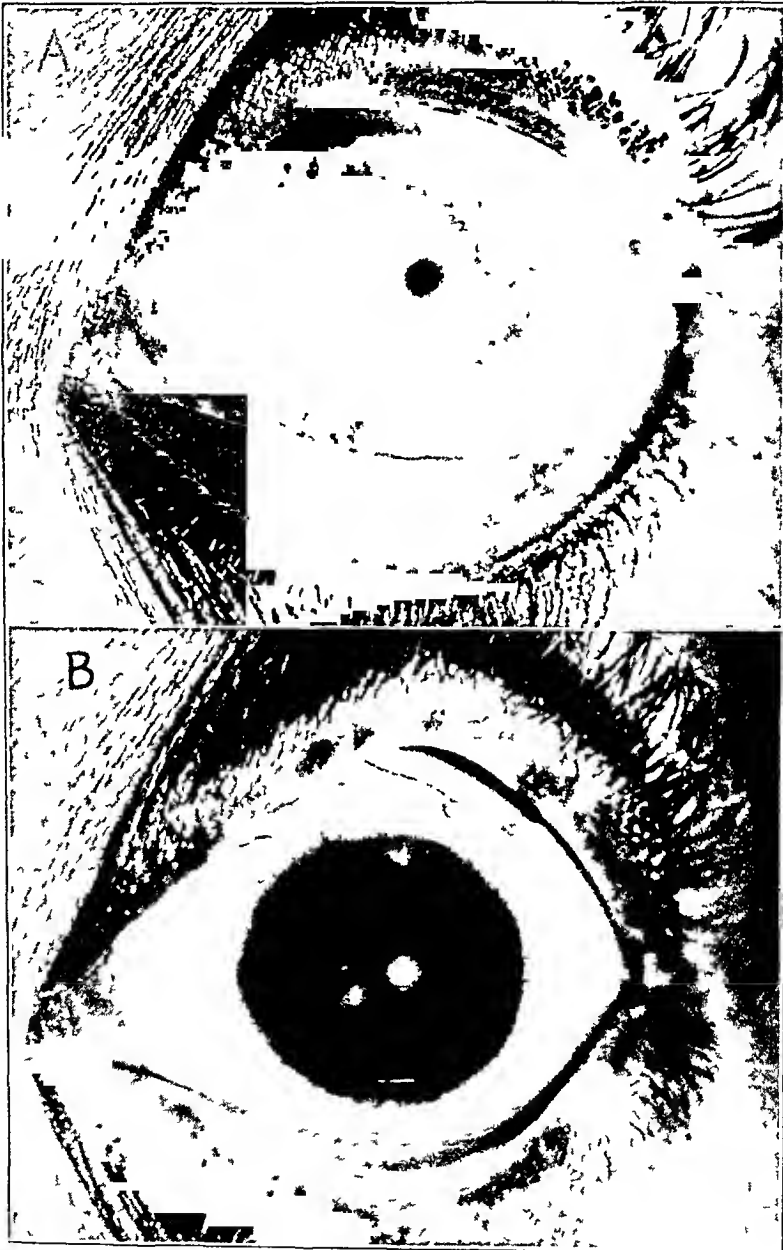


Fig 2 (W C) —Limbus in a case of vernal conjunctivitis (A) before and (B) after treatment with 10 gram seconds of beta radiation

*Results*—The results of beta radiation therapy of 60 patients with vernal conjunctivitis are presented in table 2. Forty-one patients had

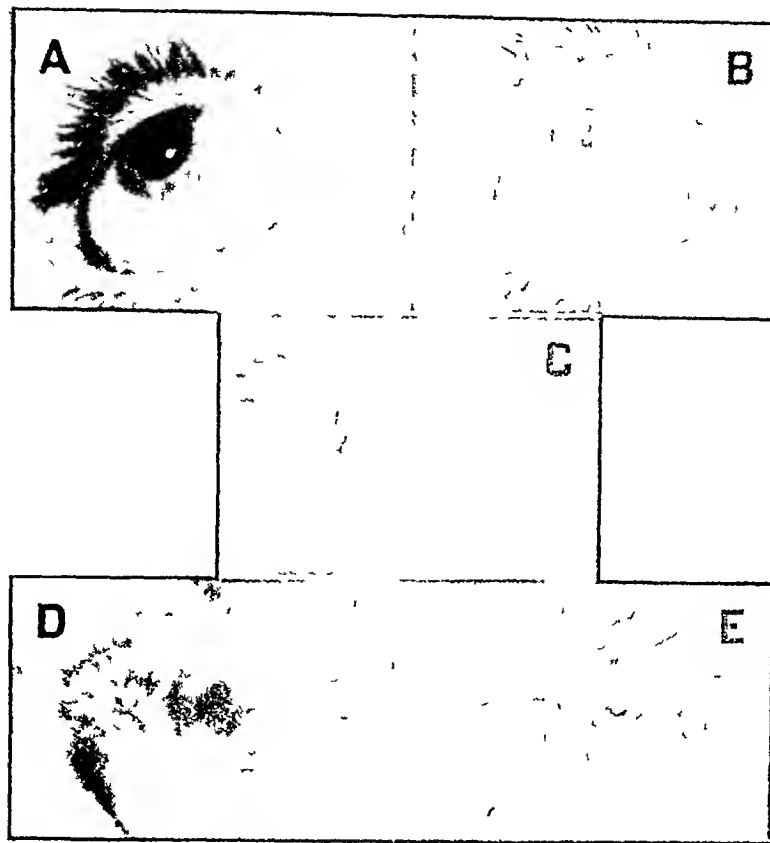


Figure 6

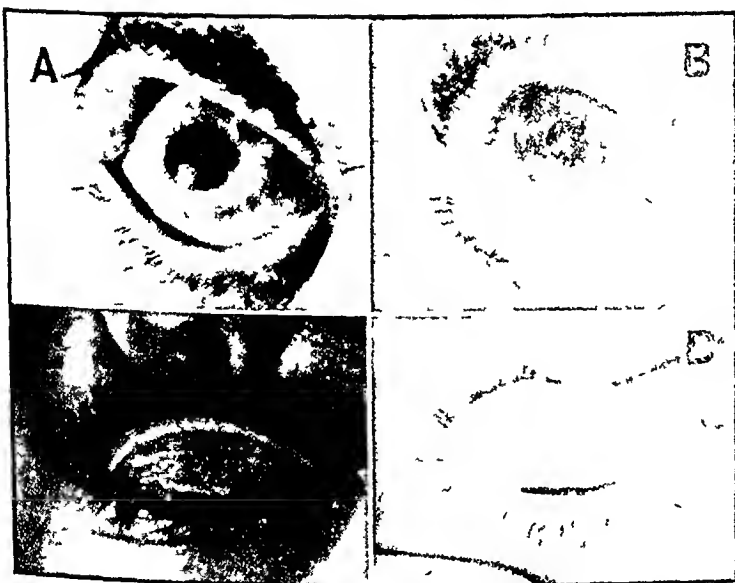


Figure 3

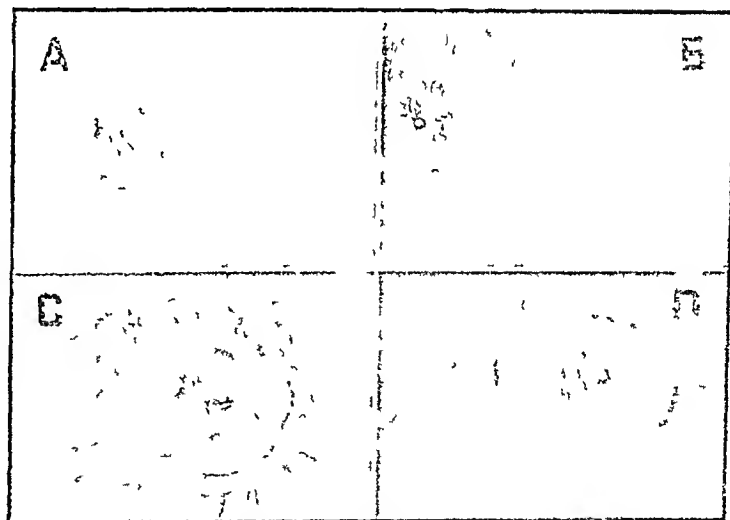


Figure 9

Fig 3—*A* (C O), severe limbal vernal conjunctivitis of four years' duration, *B*, same eye after treatment for two and one-half years with a total of 80 gram seconds of beta radiation *C* (M W), palpebral vernal conjunctivitis of two years' duration, and, *D*, same eye after nine treatments at intervals of two weeks with a total dose of 88 gram seconds of beta radiation

Fig 6—*A* (I M), right eye, showing tuberculous sclerokeratitis, *B*, same eye two weeks after contact therapy to three areas, with 5 gram seconds of beta radiation to each area, *C*, same eye six weeks after contact and spray therapy *D* (J V), deep central tuberculous keratitis, *E*, same eye after spray therapy with a total of 40 gram seconds of beta radiation

Fig 9—*A* (J D), angioma vasculosum, *B*, appearance of the eye after contact therapy with 8 gram seconds of beta radiation *C* (H C), bulbar papilloma (benign), *D*, complete disappearance of the lesion shown in *C* after spray and contact therapy with 70 gram seconds of beta radiation



palpebral lesions, 12 limbal lesions and 7 a combination of palpebral and limbal lesions. Patients were considered cured if no signs or symptoms remained after treatment and if there was no recurrence the next year. Patients were said to show improvement when both subjective and objective improvement occurred but a few granulations or slight discharge persisted. Patients whose conjunctivitis was apparently healed after treatment and who did not return for a check the second season were placed in the group showing improvement. Patients were considered to show no improvement when severe symptoms continued and the follicles persisted after adequate therapy.

With the lesions of beta ray therapy, 30 per cent of the 60 patients healed, 30 per cent showed improvement, and 7 per cent showed no improvement.

In early cases of vernal conjunctivitis the papillae consist chiefly of proliferating young fibrous tissue, new vessels and cells of the lymphoid series. These elements are all sensitive to irradiation. In cases of

TABLE 2—Results of Beta Radiation Therapy for Vernal Conjunctivitis

	Total Number	Cure		Condition Improved		Condition Unimproved	
		Number	Per Cent	Number	Per Cent	Number	Per Cent
Palpebral	41	8	20	31	75	2	5
Limbal	12	5	42	6	50	1	8
Combined	7	5	71	1	14.5	1	14.5
	60	18	30	38	63	4	7

long-standing disease the papillae contain hyaline degeneration, which as Pendergrass pointed out, is relatively insensitive to irradiation and explains the less dramatic results in these cases.

Patients with limbal and combined lesions were usually brought to the clinic at an earlier stage in the disease than patients with the palpebral variety, and the lesions thus responded more readily to treatment. In only 1 case (C O) was the limbal lesion of long standing, and it showed the same resistance to therapy as the long-standing palpebral lesions. The slightly better results for the combined group are not significant, owing to the small number of cases.

#### TUBERCULOSIS OF THE ANTERIOR OCULAR SEGMENT

Encouraging results in the treatment of tuberculosis of the anterior ocular segment with beta radiation were reported by Woods<sup>9</sup> in 1939.

*Material*—Data on 53 patients, representing 72 eyes treated since that time, are given in table 3. The duration of the disease before treatment had ranged from one week to as long as thirty years. All the cases were characterized by remissions and

<sup>9</sup> Woods, A. C. Treatment of Tuberculosis of the Anterior Portion of the Eye with Beta Rays of Radium, *Arch. Ophth.* **22**: 735 (Nov.) 1939.

TABLE 3—Data on Patients with Tuberculosis of the Anterior Ocular Segment

Name	Eye Affected	Duration Before Treatment	Vision Before Treatment	No of Treatments and Interval *	Total Dose, Gm Sec	Final Vision	Final Clinical Picture and Period of Observation
D L	R E	18 yr	20/30	34 in 6 yr	223 5	20/50	Healed 2 yr
	L E	18 yr	20/15	13 in 6 yr	88	20/15	Healed 6 yr
E G	R E	1 yr	20/20	5 courses, 3 wk intervals	93 4	20/15	Healed 1 yr
	L E	1 yr	20/20	3 courses, 3 wk intervals	32	20/15	Healed 1 yr
M D	R E	12 yr	Hand movements	3, weekly	10 2	Hand movements	Healed 2½ yr
E Y	R E	1 mo	20/20	3, weekly	15 3	20/15	Healed 1 yr 4 mo
E H	L E	1 yr	20/30—1	3, weekly	25 0	20/20	Healed 1 yr
A R	R E	3 yr	20/30	5, monthly	33 3	20/30 +4	Healed 2 yr
	L E	3 yr	20/70	5, monthly	73 2	20/30 —3	Patient wrote of flare up 2 yr after treatment, eye improved
M M	R E	5 yr	20/200	15 in courses	86	20/100	Improvement, 2 slight flare-ups in next 2 yr
	L E	5 yr	6/200	14 in courses	82 2	20/60	Improvement, patient not seen after discharge in 1910
G S	R E	30 yr	Hand movements	1911 6	43 6	20/70	Improvement, 1 flare up in 2 yr after treatment
	L E	30 yr	20/30	1912 6	31 1	20/20	Healed, patient followed 2 yr
E M	Both	20 yr	20/30 +3	1937 1	16 0	20/40	Healing, follow up for 2 yr
			20/15	1940 3	24	20/15	Improvement patient wrote of flare up 5 yr later
E M	R E	5 yr	20/30	3, weekly	31 7	20/30	Improvement relapse 1 mo after discharge
H R	R E	2 yr	20/15	16 in 2 yr	157 3	20/15	Improvement, flare up twice when treatment stopped, now on maintenance therapy
	L E	2 yr	20/15	8 in 1½ yr	57	20/15	Improvement, patient followed 2 yr
C H	R E	5 yr	20/30	1942 15	151 total	10/200	No improvement, secondary glaucoma, cyclodlathermy
	L E	5 yr	20/70	1938 1939 18	228 over periods	20/40	Improvement for 5 yr, then flare up, left eye quiet with therapy 1 yr eye quiet
E M	L E	9 yr	5/200	1938 9 courses	Exact Eye enucleated not known†		Improvement, then down hill course
R M	R E	3 wk	10/200	3 over 2 areas in 72 wk	30	20/30	Healed, follow-up 1 yr
E M	R E	7 wk	20/30	4, 2 courses	40	20/15	Healed, follow up 1 yr
E C	L E	1 wk	20/30	2, 1 wk interval	20	20/30	Healed, follow up 6 mo
I M	R E	3 mo	20/30	3 treatments 5 Gm sec each to 3 areas	15, contact and spray	20/30 +4	Healed, follow up 1 yr
F M	L E	16 yr	20/30 —3	3 courses over 3 yr	1938 38 1941 20 1944 8	20/50, senile immature cataract	3 recurrences response each time to irradiation, now healed 1 yr

\* The numeral not otherwise qualified indicates the number of treatments

† Treated at the Kelly Hospital

TABLE 3—Data on Patients with Tuberculosis of the Anterior  
Ocular Segment—Continued

Name	Eye Affected	Duration Before Treatment	Vision Before Treatment	No. of Treatments and Interval *	Total Dose, Gm See	Final Vision	Final Clinical Picture and Period of Observation
A	R E	1 mo	20/30 —2	4	19	20/30	Healed, follow up 1 yr
B M	R L L E	6 yr 6 yr	20/100 20/200	7, 3 courses to each eye	65 66	20/100 20/100	Improvement, 1 yr Improvement, 1 yr
P M	R E	1 mo	20/20	1	12	20/20	Improvement, eye quiet 6 mo to date
M V	L E	Many times in 20 yr	5/200	3 courses	65	20/70 (pin hole)	Improvement, eye quiet now 10 mo, to date
A R	L E	6 wk	Hand move- ments 2 ft	7, 2 wk intervals	68	20/20	Healed 1 yr
A B	R E	3 wk	20/30	4	52	20/30	Improvement, follow up 6 mo
R P	R E	5 days	20/40	4	253	20/15	Healed, follow up 3 yr
H G	R E	1 yr	20/30	5, 1 course 1911 and 1912	406	20/20	Healed, follow up 2 yr 9 mo
	L E	5 yr	20/15	5, 1 course 1911 and 1912	595	20/30	Healed, follow up 2 yr 9 mo
M P	R E	2½ yr	20/50	16 in 2 yr	831	20/50	Healed, follow up 4 yr
	L E	2½ yr	20/50	16 in 2 yr	683	20/15	Healed, follow up 4 yr
J O	L E	5 yr	Light percep- tion, cata- ract	5 weekly then maintenanc dose at 2 mo intervals	75	Light perception	Healed, follow-up 3 yr
A R	L E	3 mo	20/200	13 in 14 mo, in courses	1001	20/10	Healed, follow up 2 yr
A O	R E	10 yr	Hand move- ments cataract	13, in courses	80	Hand movements	Healed, follow up 3 yr
M L	R E	1 yr	20/15	4	40	20/15	Healed, follow up 2 yr
	L E	1 yr	20/70	4	40	20/15	Healed, follow up 2 yr
J V	R E	1 mo	20/15 —3, im- mature cataract	6	44	20/10	Healed, follow up 1 yr
	L E	1 mo	Count fingers, 2 ft	6	40	20/40	Healed, follow up 1 yr
H C	R E	4 yr	20/70 +1	3	183	20/30	Healed, follow up 3 yr
	L E	6 yr	20/20	3	183	20/15	Healed, follow up 3 yr
E C	L E	1 mo	1/200	4	284	20/30	Improvement, follow up 10 mo
J S	R E	8 yr	5/200	3 (both eyes)	255	20/70	Improvement, follow up 9 mo
	L E	8 yr	Count fingers 6 ft		255	20/70	Improvement, follow up 9 mo
P D	R E	1 mo	Hand move- ments	14 over 8 mo	1372	20/30 +2	Improvement, follow up 9 mo
J B	R E	5 yr	20/70	1938 11 1942 13	212	20/40	Improvement, 1 relapse, patient followed 7 mo after
M L	R E	1 mo	20/30 —2	3	15	20/30	Healed, 1 yr
M D		1 mo 14 yr	2/200 20/20	1937 4 1940 2	Fract? 20/20 167	20/20	Healed, 3 yr Improvement patient not seen after discharge



TABLE 3—*Data on Patients with Tuberculosis of the Anterior Ocular Segment—Continued*

Name	Eye Affected	Duration Before Treatment	Vision Before Treatment	No of Treatments and Interval *	Total Dose, Gm Sec	Final Vision	Final Clinical Picture and Period of Observation
Y	L E	5 yr	Hand movements 3 ft	8 with 2 wk intervals	51.5	20/15	Healed, 3 yr
A J	R E	2 mo	4/200	8 with 2 wk intervals	88	20/40	Healed, 1 yr
E M	R E	1 yr	10/200	1938 7 1939 1	57.29	20/100	Improvement, 1 relapse, which responded to treatment
C D	R E	10 yr	20/50, immature cataract	41 over 3 yr	173.7	20/20	Improvement, number of small exacerbations, controlled with irradiation
	L E	10 yr	20/200 immature cataract	17 over 3 yr	79.4	20/100	Improvement
M S	R E	5 yr	20/70	25 over 3 yr	136	20/60	Improvement 2 flare ups in 3 yr
	L E	5 yr	5/200	25 over 3 yr	136	20/200	Improvement, 2 flare ups in 3 yr
A T	R E	1 mo	3/200	3 weekly, 10 maintenance doses	84	20/60 —1 (pin hole)	Healed, 2 yr
I T	R E	10 yr	20/30	1941 1942 3	37.3	20/70	No improvement
	L E	10 yr	Count fingers	1941 1942 3	37.3	Counting fingers	No improvement
A S	R E	10 yr	20/40	30, weekly, then monthly	146.9	20/70	No improvement, follow up 2 yr
	L E	10 yr	20/40	29, 1 course, then monthly	131.1	Light perception	No improvement
A D	R E	4 mo	20/200	3	17.2	20/200	Healed, follow up 4 yr
E R	L E	6 yr	20/50	7	39.9	20/30	Healed, 1 yr
M C	R E	2 mo	20/40	4	36	20/40	Healed follow up 1½ yr
J E	R E	1 mo	20/40	4	30	20/30	Improvement, 6 mo
H C	R F	3 mo	20/20	3	25	20/20	Improvement, 6 mo

exacerbations. A few of these patients had been followed in the Wilmer dispensary for ten to fifteen years, and from the data on these patients an attempt was made to evaluate the length and severity of exacerbations with and without beta therapy. In any such problem controls are extremely difficult. In the over-all picture, however, it seemed clear that treatment shortened the course of the attack and lessened its severity.

In 1 instance it was possible to treat one eye and use the other as a control. The patient, A R, had severe bilateral central keratitis, which was at first thought to be due to congenital syphilis. However, intensive penicillin therapy produced no improvement, and the lesion gradually assumed the appearance of tuberculous keratitis (fig 4 A and B). Beta irradiation was started on the more severely affected left eye on Dec 28, 1944. Seven applications to the limbus at intervals of two weeks, using the spray technic, with a total of 52 gram seconds, were given. Both eyes remained intensely inflamed for eight weeks. By the tenth week the right eye was almost quiet, the left eye still showed slight pericorneal congestion, but its cornea was clearer than that of the right eye. At the end of four months the treated (left) eye was the better one, with less deep scarring and vascularization (fig 4 C and D). Figure 5, a drawing of the right eye made with the slit lamp, shows the corneal nebulas and deep vessels, which were not present in the treated (left) eye.

An example of improvement in milder lesions is the case of I M, a woman aged 50, who was first seen Oct 20, 1944 with typical sclerokeratitis of the right eye of three months' duration. She had been hospitalized for one month by her local physicians for treatment with typhoid vaccine and sulfonamide compounds, and the usual local treatments had been employed, without improvement. Figure 6 *A* shows this eye before treatment, figure 6 *B*, the eye two weeks after the first treatment, in which a dose of 5 gram seconds was given by contact in three areas, at the site of the scleral inflammation and at the limbus from 3 to 6 o'clock. Symptoms were notably reduced after the first treatment and disappeared completely after the second treatment, in which 5 gram seconds of radiation was sprayed over the limbus at 3 to 5 o'clock. A third spray treatment with 5 gram seconds of radiation was given in the sixth week. When checked, six weeks after the last treatment, the eye had

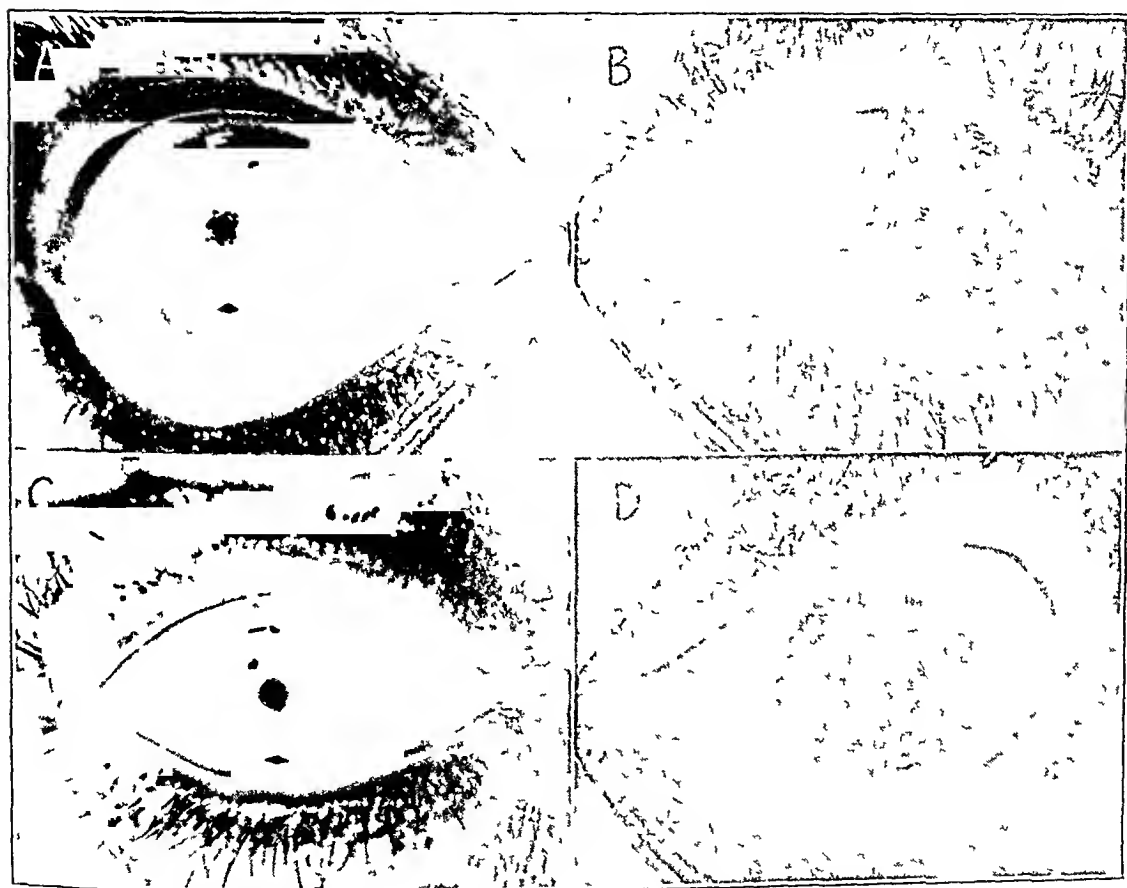


Fig 4 (A R) — *A*, right eye (untreated control) and, *B*, left eye, with deep central tuberculous keratitis, *C*, right eye at the end of twelve weeks, without treatment, *D*, left eye, after treatment for twelve weeks with 52 gram seconds of beta radiation administered by spray to the limbus

been asymptomatic for nine weeks, and the lesion had remained clinically unchanged for five weeks (fig 6 *C*). Vision was 20/30 before and after treatment. The eye has remained quiet for one year, to date.

Another patient, J V, had had violet keratitis (fig 6 *D*) for three months. The sclerosing of the superficial vascular trunks by irradiation, with clearing of the cornea as the active process quieted down, is seen in figure 6 *E*. The total dose administered by the spray technic was 40 gram seconds, given in two courses. Vision improved from counting fingers at 2 feet (30 cm) to 20/40.

**Results** — Table 4 gives the results of treatment for the 72 eyes with tuberculosis of the anterior ocular segment. Lesions were considered

healed if the eye was quiet, with no corneal infiltrates, aqueous flare, nodules on the iris or keratitis punctata. These eyes were all kept under observation for at least a year. In 7 eyes the aforementioned criteria for healing were fulfilled except that the period of observation was less than one year. These 7 eyes are, therefore, placed in the group showing improvement. Eyes were considered to show improvement if after therapy they were asymptomatic and showed no more than residual conjunctival hyperemia, no aqueous ray and inactive corneal infiltrates. Eyes classified as unimproved showed no alleviation of symptoms and a progression of the disease in spite of adequate therapy. Of the 72 eyes, the lesions of 52.8 per cent were considered healed after treatment, the condition of 38.9 per cent was improved, and that of

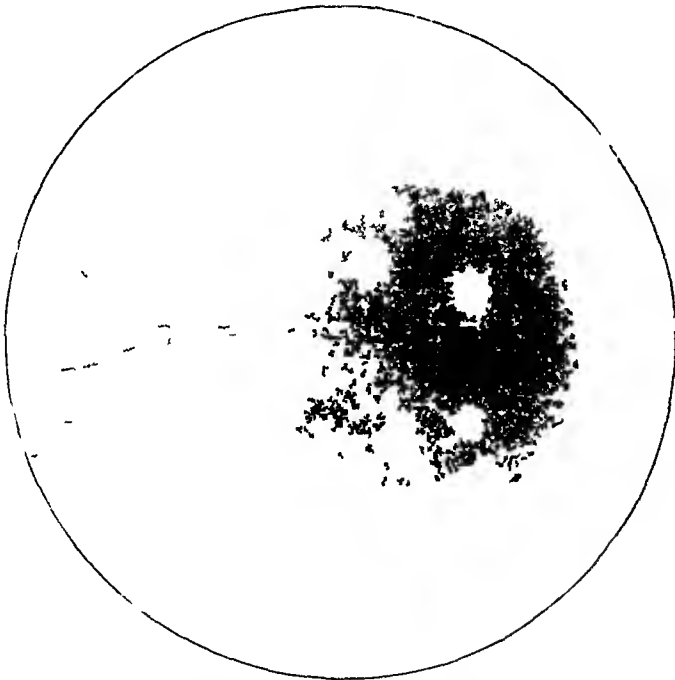


Fig. 5 (A. R.)—Slit lamp drawing of the right eye, as a control, showing residual nebulas and vascularization, which are not present in the left (treated) eye.

8.3 per cent showed no improvement in spite of adequate therapy. Since any clinical classification, such as "healed," "improved" and "unimproved" presents obvious difficulties, a comparison of vision before and after treatment is especially interesting (table 5).

Vision was improved two lines or more in 42 per cent of the eyes, maintained in 46 per cent and decreased in 9 eyes, or 12 per cent. The decrease in vision in 2 of the 9 eyes was due to the progress of senile cataracts.

*Comment*—A comparison of the clinical and visual results is interesting, as it shows a close correlation between the total number of eyes in which the lesions were considered healed and improved and the total

number of eyes in which vision was either improved or maintained. This suggests that the clinical observation of amelioration of symptoms and shortening of the duration of the disease were indications of an actual decrease in severity of the lesion, with less permanent damage to the eye.

In general, active treatment was continued as long as improvement occurred. Healing occurred in 1 case after a total of 31.9 gram seconds of beta radiation had been administered, in another case 223 gram seconds of radiation was given over a four year period, during which time there were two exacerbations. This eye has now been healed for two years.

As a rule, in the treated eyes subjective improvement preceded objective improvement by about two weeks. Objective improvement

TABLE 4—*Results of Beta Irradiation of Seventy-Two Eyes with Tuberculosis of the Anterior Segment*

Eyes	Healed		Improvement		No Improvement	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
72	38	52.8	28	38.9	6	8.3

TABLE 5—*Comparison of Initial and Final Vision in Seventy-Two Eyes with Tuberculosis of Anterior Segment Treated with Beta Radiation*

Eyes	Improved		Maintained		Decreased	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
72	30	42	33	46	9*	12

\* The decrease in vision in 2 of the 9 eyes was due to the progress of senile cataracts.

was usually noted in about four weeks, and eyes were either quiet or greatly improved in six to eight weeks. With extremely severe lesions longer treatment was required.

While beta irradiation seemed to have a beneficial effect on the immediate attack, it did not prevent future attacks. On this basis, long term therapy in the form of tuberculin treatment was advised in all cases.

The mode of action of radiation in cases of ocular tuberculosis is unknown. It has been pointed out that both beta<sup>10</sup> and grenz<sup>11</sup> rays increase the antibody reaction in the cornea, and it may be that in this way the beneficial results are obtained.

10 Moore, J. I. Increase in Antibody Production in Cornea with Beta Rays, paper read at a meeting of residents of the Wilmer Ophthalmological Institute, Johns Hopkins Hospital, April 1946.

11 Thompson, R., Pfeiffer, R., and Gallardo, E. Stimulation of Local Antibody Formation in the Cornea by Grenz Rays, *Proc Soc Exper Biol & Med* 36: 179, 1937.

TABLE 6—Data on Patients with Benign Tumors Treated with Beta Radiation

	Name, Age	Lesion	No of Treatments and Dosage	Result
Angioma	J G 3 mo	Nevus vasculosus of earuncle, upper and lower cul de sacs and nasal portion of left upper lid, causing partial ptosis	5 treatments over 6 mo, 42 Gm sec total dose to different areas in contact with lesion	Slow resolution of lesion
	A Z 4 yr	Angioma cavernosus, bluish discoloration and thickening of skin of right upper lid with partial ptosis	3 treatments 3 wk apart, totaling 19 Gm sec, contact with lesion on both sides of lid	Complete resolution within 2 mo
	H L 5 mo	Angioma vasculosum of left upper lid and left hand	4 treatments over 5 mo, total dose 40 Gm sec, given just short of contact with lesion	Complete resolution in 5 mo
	G P	Small mulberry angioma, bulbar conjunctiva	2 treatments, 14 Gm sec each	Lesion completely disappeared in 2 mo
	Mrs G	Angioma of earuncle	2 treatments, 6 Gm sec each	Lesion completely disappeared in 4 wk
	J D	Small angioma cavernosum, inner canthus	1 treatment, 8 Gm sec each	Disappeared in 9 wk
Papilloma of lids	J K	Small, pedunculated papilloma on margin of right upper lid	1 treatment, 14.3 Gm sec	Tumor fell off in 2 wk
	J W	Papilloma, margin of right lid	1 treatment, 6.9 Gm sec	Tumor fell off in 3 wk
	H W	Papilloma, upper margin of lid	2 treatments, 9.3 and 7 Gm sec, 1 wk apart	Lesion disappeared in 1 mo
	J N	Small papilloma, left lower lid	10 and 9.75 Gm sec 1 wk apart	Lesion disappeared in 2 wk
	Mrs B	Flat papilloma, right upper lid	8 Gm sec, by contact	Lesion size in 3 wk, patient became ill and could not return for further therapy
	S C	Flat papilloma, upper lid	4 treatments, 3 wk intervals, 7, 9, 6 and 8 Gm sec, respectively	Lesion did not change treatment discontinued
	Mrs W	Pedunculated	1 treatment, 10 Gm sec	Lesion disappeared in 2 wk
	Mrs R	Flat	3 treatments, 10 Gm sec	Lesion flattened in 2 mo
Papilloma of bulbar conjunctiva	Miss P	Flat papilloma, right upper lid	3 treatments, 6 Gm sec each	Lesion did not respond surgically removed, diagnosis of nevus on section
	P U	Papilloma of earuncle	1 treatment, 7 Gm sec, contact	Lesion disappeared in 2 wk
	F R	Papilloma of earuncle	3 treatments, 26 Gm sec in contact with lesion	Lesion disappeared in 1 mo
	M W	Papilloma with granulation tissue at earuncle	7.9 Gm sec, in contact with lesion	Lesion flattened in 4 wk
Papilloma of bulbar conjunctiva	D B	Papilloma of upper cul de sac	3 treatments 2 wk apart, in contact with lesion, doses 10, 15 and 12 Gm sec	Lesion disappeared in 2 mo
	H C	Papilloma, bulbar conjunctiva (left eye)	8 treatments, total 75 Gm sec	Lesion completely disappeared, vision 20/30 when seen 2 yr later
	M S	Papilloma, bulbar conjunctiva (left eye)	4 treatments, each in contact with lesion in 4 areas total dose 57 Gm sec	Lesion completely disappeared in 2 mo, vision 20/20 3 yr later no recurrence

TABLE 6—Data on Patients with Benign Tumors Treated with Beta Radiation  
—Continued

Name, Age	Lesion	No. of Treatments and Dosage	Result
W G	Papilloma partially covering both corneas, lesion in right eye surgically removed, base irradiated, left eye irradiated only	R. E. 2 treatments, total 7 Gm sec L. E. 5 treatments, total 10 Gm sec	Both lesions completely disappeared
A G	Papilloma marking left cornea	5 contact treatments, total 15 Gm sec	Lesion cleared and remained clear, as patient wrote 1 yr later
D S	Papilloma at limbus early	3 treatments total 32 Gm sec	Disappeared in 8 wk, patient followed 8 mo

#### BENIGN TUMORS OF THE LIDS AND CONJUNCTIVA

Removal of small benign tumors of the lids and conjunctiva is usually carried out for cosmetic reasons, thus, a form of therapy which will produce the least residual scar is important. In some cases the surgical approach is more expedient and more satisfactory, in others irradiation is more desirable. It is important for the ophthalmologist to differentiate between benign and malignant lesions, and in case of any doubt a biopsy should be done. Most malignant lesions require deeper and more intensive therapy and should be referred to the radiologist.

The data on 24 cases of benign tumors of the lids and conjunctiva are given, with the dose and the length of time necessary to effect a disappearance of the lesion (table 6). Angiomas as a rule respond well to irradiation, except the nevus flammeus, or port-wine stain. In contrast, the nevus vasculosus, or strawberry mark frequently seen at the caruncle or involving the cul-de-sacs, responds dramatically.

J G, a 3 month old baby, had a lesion involving the caruncle, nasal upper and lower cul-de-sacs and the nasal portion of the left upper lid (fig 7 A). Five treatments, with a total dose of 42 gram seconds, administered in contact with the lesion were given over a period of six months. With this therapy there was progressive improvement (fig 7 B).

A 4 year old boy (A Z) had thickening of the lid and partial ptosis, due to angioma cavernosum. This lesion is usually completely subcutaneous and consists of dilated vessels which produce an elevation and give a bluish color to the skin (fig 8 A). Five months later, after three treatments, with a total of 198 gram seconds, his condition was much improved (fig 8 B). The response with this type of lesion is excellent but not so dramatic as that with nevus vasculosus.

Figure 9 A shows a small angioma vasculosum near the inner canthus in a 4 year old girl, J D. One contact treatment with 8 gram seconds of beta radiation caused complete resolution of the lesion (fig 9 B).

Papilloma of the bulbar conjunctiva presents the most frightening picture of the benign tumors. Its growth is usually rapid, and it fre-



Fig 7 (J G) —*A*, angioma of the caruncle and the upper and lower cul-de-sacs, *B*, appearance of the eye one year after therapy with 42 gram seconds of beta radiation

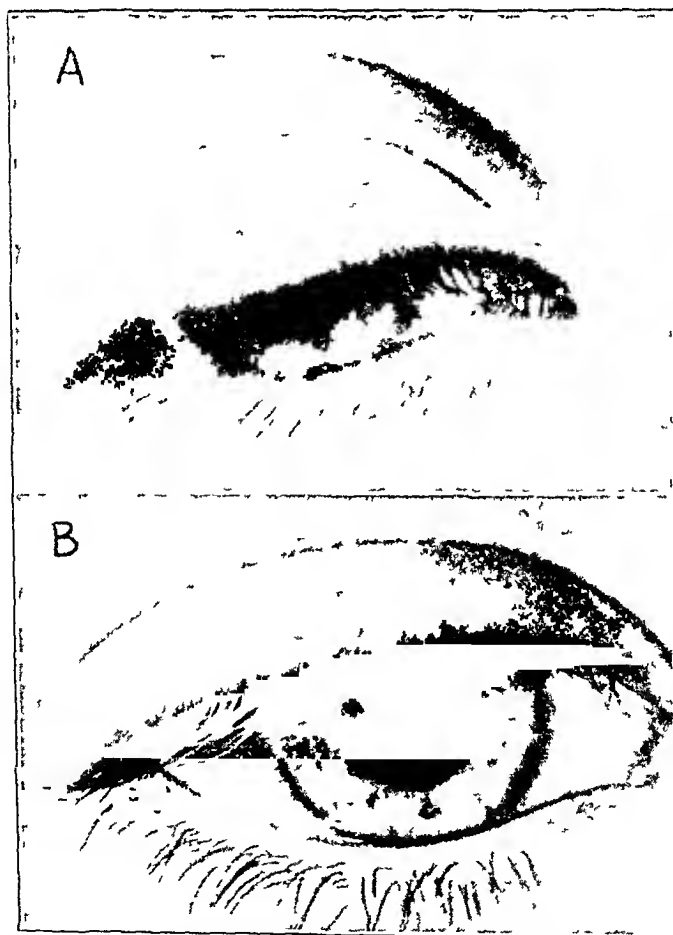


Fig 8 (A Z) —*A*, angioma of the upper lid in a 5 year old boy, *B*, appearance of the eye five months after contact treatment with 198 gram seconds of beta radiation

quently extends so far over the cornea that it affects the vision. In cases of this tumor biopsy is routinely done to rule out epithelioma. Both the benign and the malignant forms, however, respond well to beta radiation therapy.

Figure 9 C shows a typical bulbar papilloma of eight months' duration in a man aged 60. Thirty gram seconds of radiation given by spray and contact made the lesion almost completely disappear, and the patient did not return for two years.

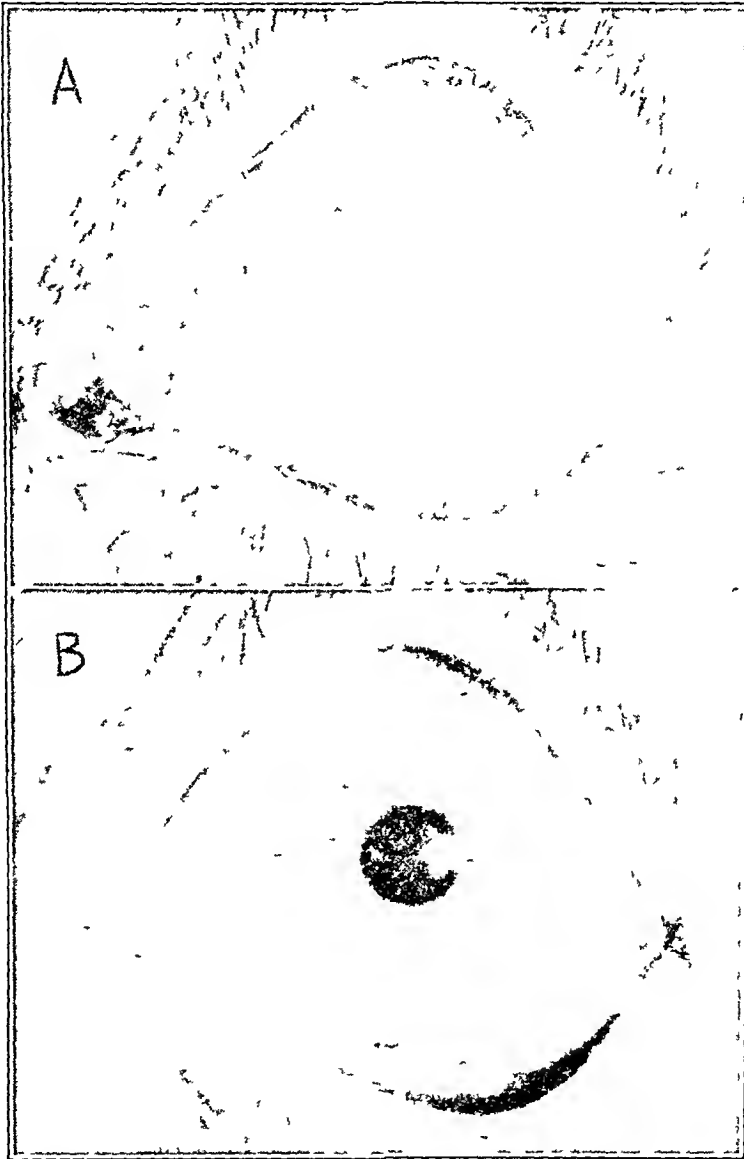


Fig 10 (M S)—*A*, bulbar papilloma, *B*, appearance of the eye shown in *A* after ten weeks of contact and spray therapy with a total of 57 gram seconds of beta radiation.

At this time he had a mild recurrence and was given an additional 45 gram seconds as contact and spray therapy. The eye has remained quiet for three years, to date, with vision of 20/30 (fig 9 D).

A woman aged 64, with a typical bulbar papilloma of three months' duration, was seen first on May 8, 1943 (fig 10 A). Biopsy confirmed the clinical diagnosis. Contact treatment, consisting of a total of 57 gram seconds of radiation, was given



in four doses over a period of six weeks. In ten weeks the lesion had completely disappeared (fig 10 B). The patient has been followed now for three and one-half years, and the eye has remained quiet, with vision of 20/20.

The pedunculated papillomas of the lids usually dry up after one, or at most two, treatments. One patient with this type of lesion is shown before treatment (fig 11 A) and after contact therapy with a dose of 5 gram seconds (fig 11 B).

Papillomas of the conjunctiva respond rapidly and leave little residual scar. D. B., a 10 year old Negro girl, had a mass in the upper cul-de-sac which on section proved to be a papilloma (fig 12 A). Three contact treatments were given, for a total dose of 37 gram seconds, at two week intervals. The lesion two months later is shown in figure 12 B.

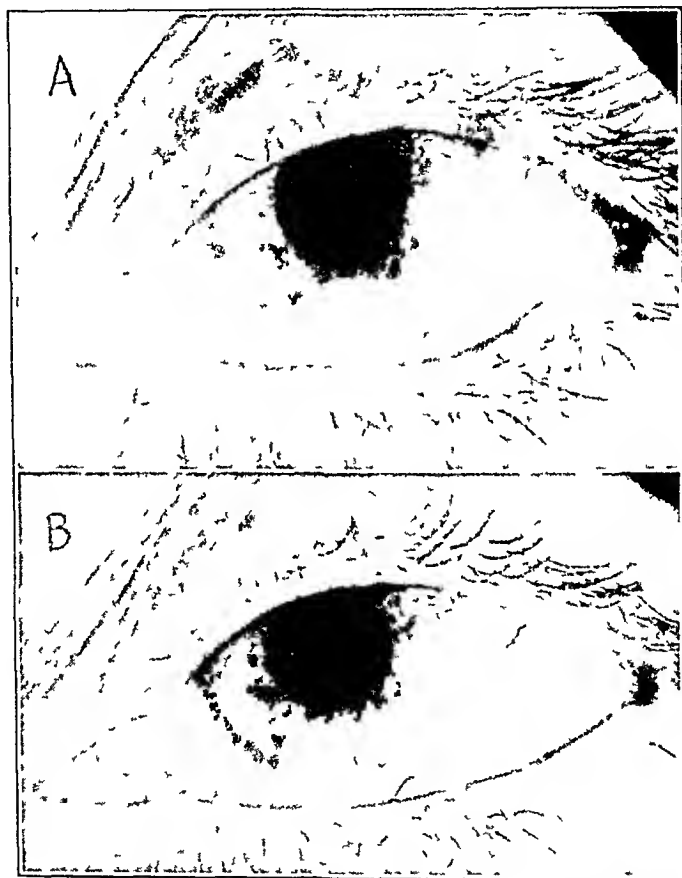


Fig 11—A, small papilloma of the lid, B, appearance of the eye after contact therapy with 5 gram seconds of beta radiation.

I wish to emphasize that the removal of benign tumors of the anterior ocular segment for cosmetic reasons is in the province of the ophthalmologist and that beta irradiation is practical and gives excellent results.

#### CORNEAL LESIONS

*Punctate Keratitis*—Five patients with typical punctate keratitis which had responded to no other therapy were sent to the radium clinic for treatment. Notwithstanding the fact that punctate keratitis can be

produced by beta irradiation, 2 of these patients were given low doses, 3 to 5 gram seconds, 3 were given a full course of treatment, with 18 gram seconds. One patient in the latter group showed improvement and then relapsed. The other 4 patients showed no improvement whatever.

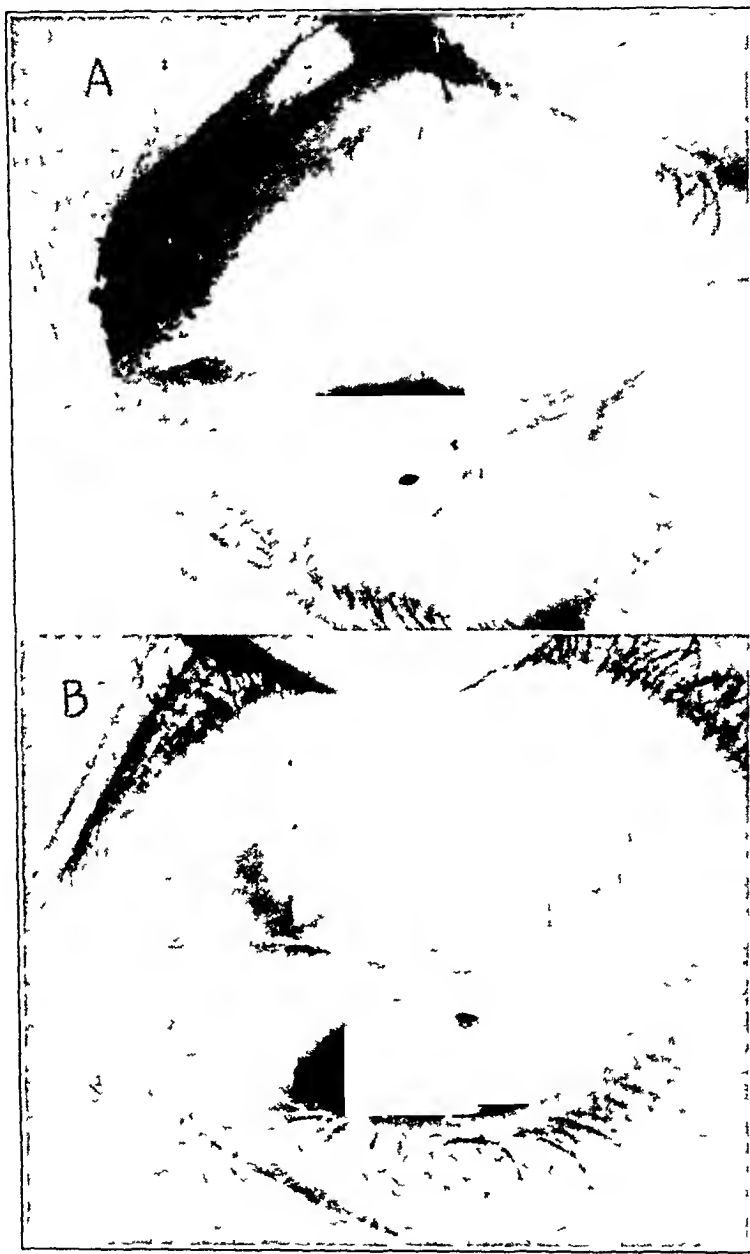


Fig 12 (D B) —*A*, papilloma of the cul-de-sac, *B*, appearance of the eye after contact therapy with 37 gram seconds of beta radiation

*Corneal Ulcer* —Eleven patients with corneal ulcer, due either to staphylococcic or to mixed infection which had not responded to local therapy, were given one course of treatment. One patient showed notable improvement, but a marginal infiltrate shortly developed in the other eye. The picture became typically that of tuberculous ker-

atitis, which rapidly responded to radiation therapy. The infection in the first eye was probably also on this basis, with a superimposed secondary infection.

In 6 patients the treatment seemed to make the ulcer definitely worse, and 3 were admitted to the hospital. In 2 of these 3 patients conjunctival flaps were pulled, as the cornea became so thin that perforation was feared. The third patient seemed to improve with local therapy in the hospital, and the ulcer slowly healed. In 4 eyes with less

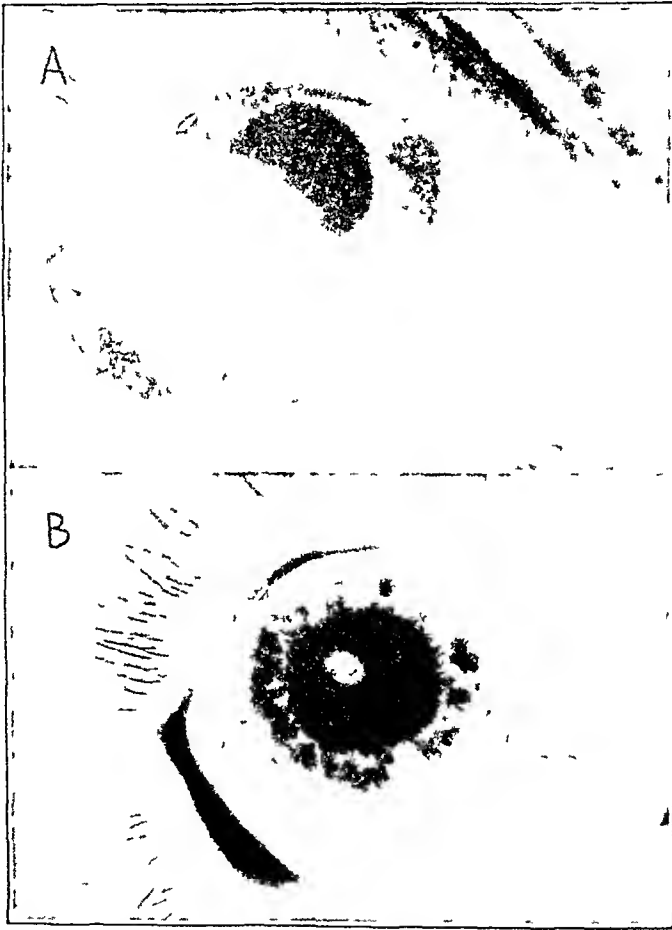


Fig 13 (L G) —A, acne rosacea keratitis, B, appearance of the eye after three courses of spray and contact therapy, with a total of 45 gram seconds of beta radiation.

purulent discharge only questionable improvement occurred after the first course of treatment. However, after the discouraging experience with 3 patients who required admission to the hospital, a second course of therapy was not given. Here, again, the result is as would be expected, in that irradiation hastened the breakdown of the already damaged cells.

*Chronic Ulcer*—Nine patients with corneal ulcer considered to have resulted from acne rosacea keratitis were treated. These ulcers consisted of stromal infiltrates, usually in the lower corneal quadrants, into

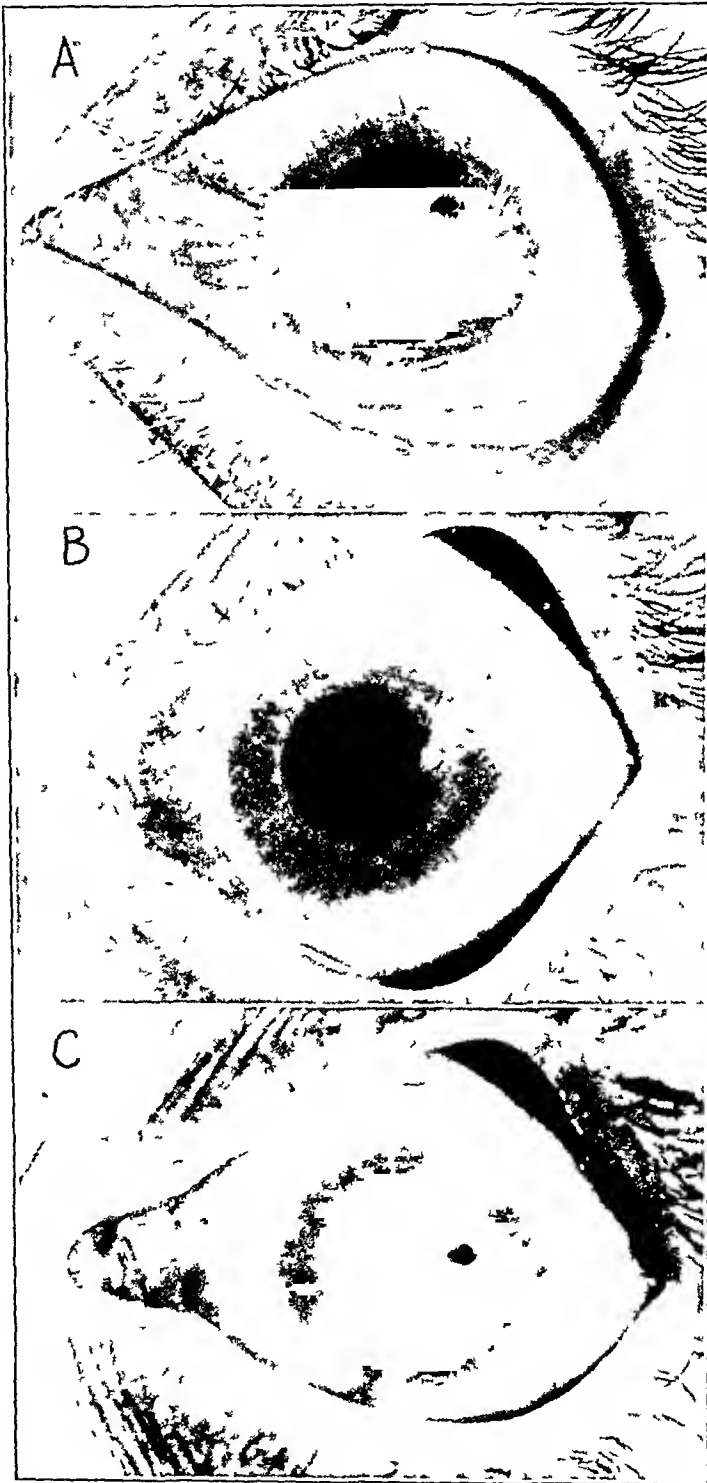


Fig 14 (C S)—*A*, sulfur dioxide burns, *B*, temporal half of the limbus after treatment, *C*, the limbus after contact treatment with 5 gram seconds of radiation to each area

which went deep and superficial vessels. The epithelium usually was intact, but on some occasions staining occurred. Treatment at the

limbus produced occlusion of the vessels, and with the decrease in vascularity the corneal lesions of 6 patients improved. In the 3 patients who showed no improvement the purulent discharge and conjunctival factor were prominent features.

The corneal lesion of L. G., a woman aged 50 with acne rosacea keratitis of six months' duration (fig 13 A), received three courses of spray and contact therapy with a total dose of 45 gram seconds. In a

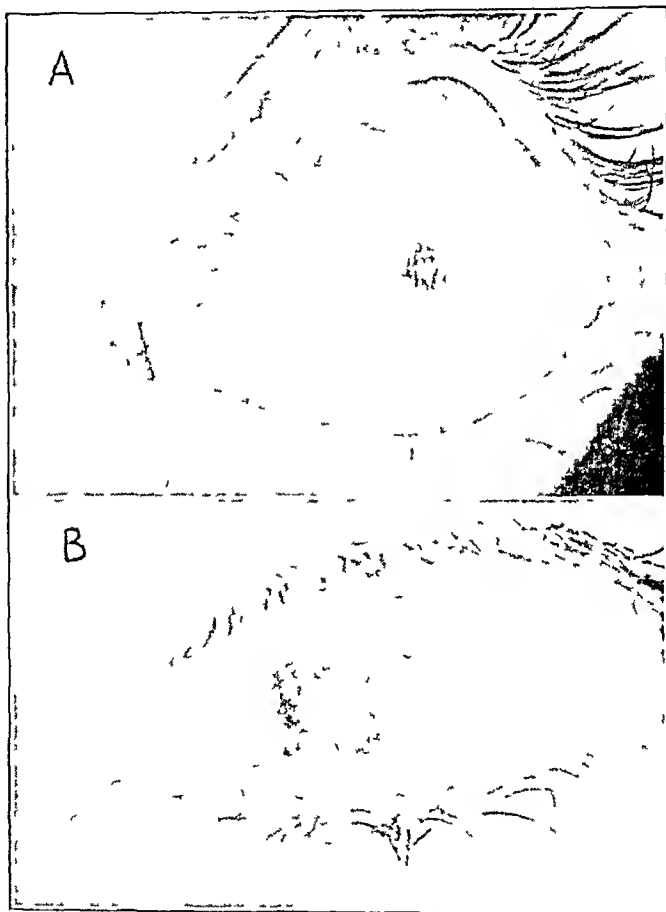


Fig 15 (L. K.)—A, appearance of the eye after lamellar laminectomy, showing invading limbal vascularization, B, limbus treated with spray therapy only

follow-up observation of two years there has been no recurrence (fig 13 B).

*Corneal Scars*—A great variety of corneal scars have been treated, and the results are extremely difficult to evaluate. Old dense scars or scars with deposits of calcium show no change, even after prolonged therapy.

Recent corneal lesions with thickening of the stroma and vascularization, on the other hand, do seem to show clearing with treatment although here a control is difficult.

An illustrative case is that of C S, whose left eye sustained a sulfur dioxide burn (fig 14 A). During the past year many kinds of local treatment had been tried, without signs of improvement. Vision was reduced to 4/200 and was not improved with the pinhole disk. The eye was extremely painful, and there were intense photophobia and lacrimation. The temporal half of the limbus received 5 gram seconds of beta radiation by contact, and the vessels in this area were occluded (fig 14 B). Vision improved to 20/200. Figure 14 C shows the nasal half of the limbus after treatment. Therapy was given at four week intervals, with a total



Fig 16 (W T) —A, peculiar corneal lesion of unknown origin, in a Negro, appearance of the eye after treatment of 40 gram seconds of radiation to the limbus

dose of 5 gram seconds administered by contact to each area and 10 gram seconds by spray. Vision one year later was 20/70, with the pinhole disk it was 20/50. The eye was asymptomatic.

In this case vascularization played a large part and with beta irradiation it was possible to occlude the vessels. Young fibroblasts are sensitive to irradiation, and their activity is inhibited. In consider-

ing this feature, however, the relative sensitivity of the stromal cells is important, and to date we have no experimental evidence to show they are more resistant than the invading fibroblasts

In cases of lamellar keratectomy routine treatment with beta rays is given to the limbus to prevent vascularization. The best results have been obtained with a course of treatment on the fifth to the seventh postoperative day, and again on the twenty-first day. The applicator is placed as close to the limbus as possible, and the circumference is treated by quadrants, using the spray technic. An attempt is made to confine

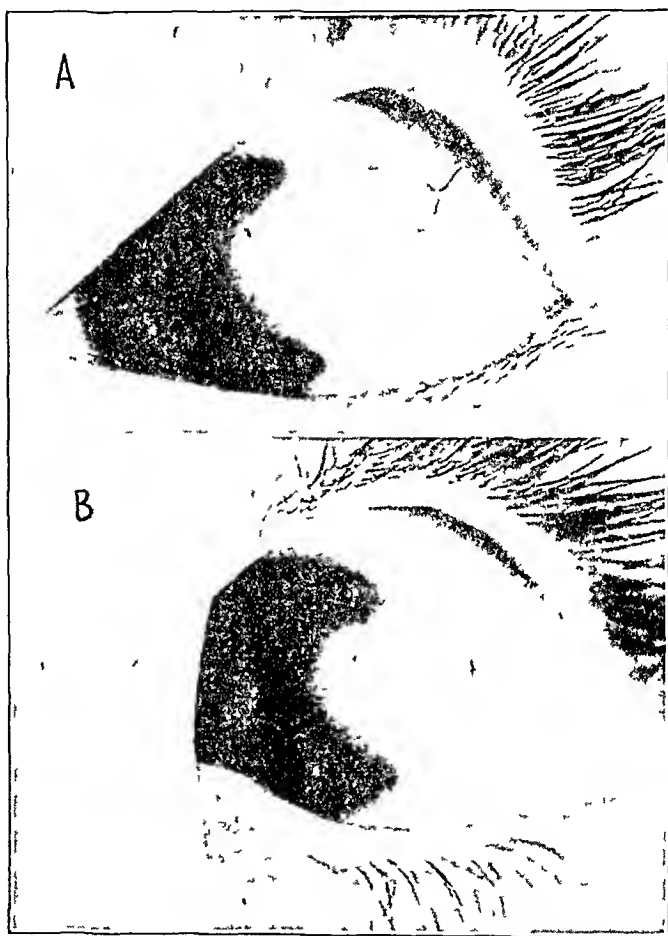


Fig. 17 (B C) —*A*, conjunctival flap, *B*, conjunctival flap after contact and spray therapy

the treatment chiefly to the limbus and the conjunctiva, rather than to spread the rays over the new corneal epithelium. When irradiation is delayed until new vessels have already entered the cornea, larger doses are required to cause occlusion. This is produced most satisfactorily by contact treatment over the vessel at the limbus.

The eye of L. K., a woman aged 28, with fatty degeneration of the cornea is shown after lamellar keratectomy (fig. 15 *A*). After operation vascularization at the

limbus was controlled with beta rays (fig 15 *B*) The vessels developed clubbed ends and did not extend farther

After keratoplasty beta radiation is immediately used if there is any evidence of formation of new vessels or of old vessels opening up, for the superficial vascular process can in most cases be controlled by this method Deep vessels are more difficult to treat, and in some instances it is necessary to use actual cautery Corneal clouding due to other causes is not helped by irradiation, and treatment is contraindicated

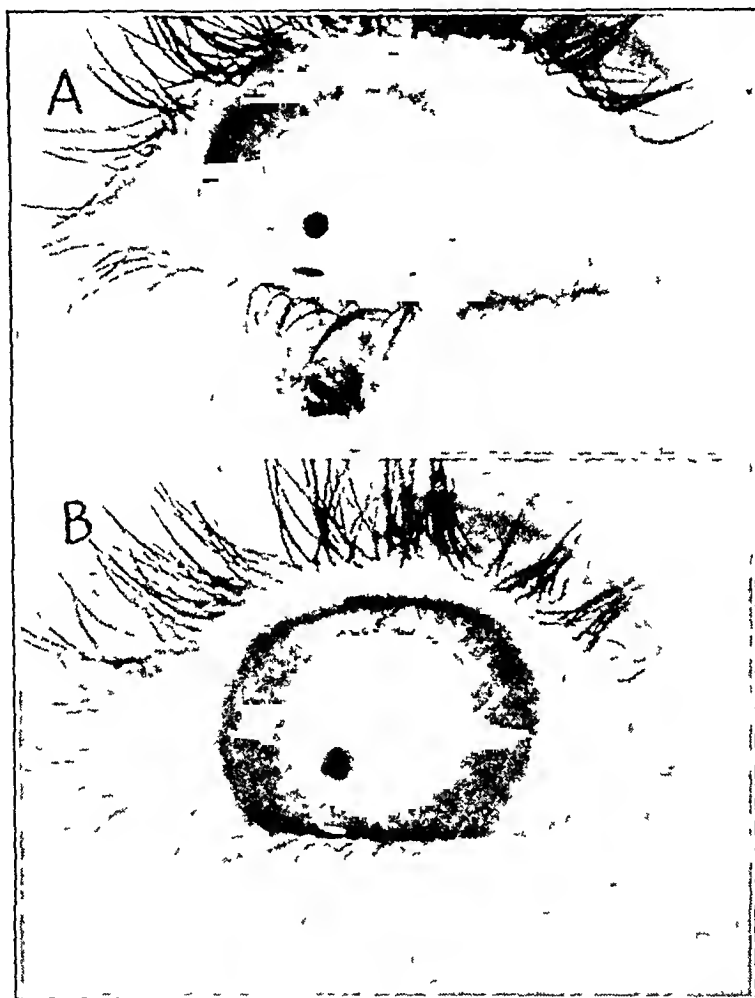


Fig 18 (N V) —*A*, granulation tissue in a neglected chalazion, *B*, appearance after therapy with 10 gram seconds of beta radiation

Figure 16 *A* shows a peculiar corneal vascularization which had persisted for nine months in a Negro aged 23 A complete survey of his case revealed no etiologic factor He was treated with contact and spray irradiation to the limbus, with a total dose of 40 gram seconds Figure 16 *B* shows the eye eight weeks later

*Pterygiums and Pseudopterygiums*—Eighteen patients with pterygiums were treated, in only 1 did treatment seem slow in yielding results, and operation was performed In cases in which there is a recurrence after operation, beta irradiation is especially valuable Contact therapy gives the more satisfactory results



Conjunctival flaps over the cornea and granulation tissue can be flattened and made avascular

B C had a severe corneal ulcer after an injury A conjunctival flap was pulled over the cornea to save the eye Irradiation was subsequently used to flatten the flap (fig 17 *A* and *B*) In N V, a child aged 7, a neglected chalazion produced a horn of granulated tissue on the cutaneous surface of the lower lid (fig 18 *A*) One treatment, with 10 gram seconds, caused shrinkage and healing of the lesion (fig 18 *B*)

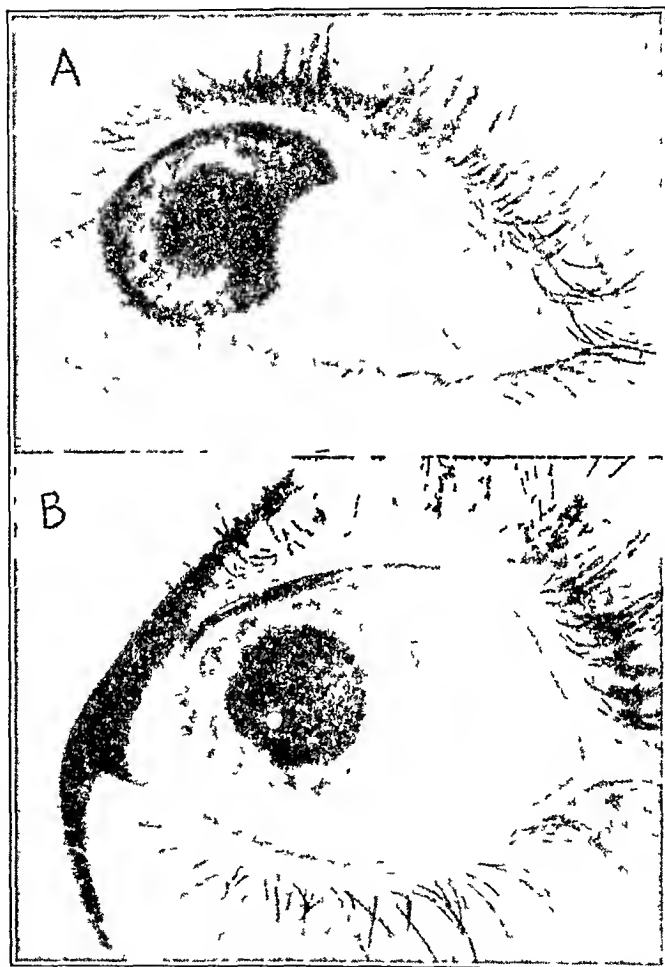


Fig 19 (Kin) —*A*, dermoid of the limbus, *B*, dermoid after contact therapy with 15 gram second of beta radiation

A dermoid at the limbus (fig 19 *A*) after contact therapy with 15 gram seconds of beta radiation was flattened and made avascular (fig 19 *B*)

*Other Lesions*—A patient with blastomycosis of the outer canthus was successfully treated by contact and spray beta irradiation, with complete resolution of the lesion Nine patients with sarcoid involving the cornea and iris were treated, without benefit In patients with corneal dystrophies, lupus erythematosus and pemphigus, no improvement was noted after adequate therapy

## CONCLUSION

1 In the treatment of vernal conjunctivitis beta irradiation gives excellent results. Recurrences are less frequent after treatment, and when they do occur are less severe. Sixty patients were treated, with cure in 30 per cent, improvement in 63 per cent and no improvement in 7 per cent.

2 In treatment of tuberculosis of the anterior ocular segment beta irradiation seems to shorten the course and decrease the severity of the symptoms, with less residual scarring of the cornea. Irradiation, however, did not prevent future recurrences of tuberculosis.

3 Small benign tumors of the anterior ocular segment can be removed by beta irradiation easily and safely, with excellent cosmetic results. Since the method is extremely easy to use in an office and requires neither hospitalization nor general anesthesia, most patients prefer it to operation. These advantages make it particularly satisfactory for work with children.

4 In treatment of corneal scars in which vascularization is a prominent feature and there is still activity irradiation appeared to be beneficial. With old, calcified and dense scars treatment is not successful.

5 Beta irradiation is ideal for preventing superficial vascularization after keratectomy and keratoplasty.

6 Granulation tissue, conjunctival flaps and pterygiums can be made avascular with contact therapy.

7 Encouraging results in the treatment of acne rosacea keratitis, with limbal application to obliterate vessels, are obtained.

8 Corneal dystrophies, sarcoid, lupus erythematosus, pemphigus, punctate keratitis and corneal ulcers due to pyogenic infections are not benefited with beta rays, and may be made worse by their use.

Dr James I. Moore treated some of the patients included in the group with ocular tuberculosis and permitted the use of these cases in the series.

Photographs were taken by Mr. Delbert Parker, of the Wilmer Ophthalmological Institute.

12 West Read Street (1)

## A SCREENING TEST FOR DEFECTIVE RED-GREEN VISION

Test Based on Eighteen Pseudoisochromatic Plates from the American  
Optical Company's Compilation

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AND

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PROBABLY the demand most frequently made of those who have had experience in testing for color blindness is for a simple means of detecting the presence of defective color vision—in other words, for a simple screening test adequate to differentiate between normal and defective color vision. The demand comes from the military services, from ophthalmologists, from industry, with its increasing use of color, and from vocational high schools, where too often a boy is trained for a trade only to find near the end of his training that he cannot meet the requirements for color vision. Tests have been produced which when properly administered and the critical scores established will meet this need, as was shown by us in previous reports<sup>1</sup>, but these tests are of foreign make and are not now available in quantity. Therefore, their evaluation has at present more theoretic than practical value. Other tests are under production which are planned both to detect the presence of deficiency in color vision and to analyze its type and amount. But lag in production affects the making of color tests as well as of automobiles, and it may be some years before these tests can be put into general use. In the meantime something must be found to serve as an adequate screening test of deficiency in color vision—something which is immediately available.

The only available test which gives promise of success for this purpose is the Pseudo-Isochromatic Plates for Testing Color Perception, compiled in 1940 by the American Optical Company for the military

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From the Knapp Memorial Laboratories, Institute of Ophthalmology, Columbia University College of Physicians and Surgeons

1 Hardy, L H, Rand, G, and Rittler, M C (a) Tests for Detection and Analysis of Color Blindness. I. An Evaluation of the Ishihara Test, *Arch Ophth* **34** 295 (Oct) 1945, (b) II Comparison of Editions of the Ishihara Test, *ibid* **35** 109 (Feb) 1946, (c) III The Rabkin Test, *ibid* **35** 251 (March) 1946

services This compilation consists of 46 plates copied from either Ishihara's Test for Colour-Blindness or Stilling's Pseudo-Isochromatic Plates for Testing the Color Sense Designed principally for the detection of deficiencies in red-green perception, it has been widely used, but with generally unsatisfactory results In part this is because of inaccurate color reproduction and a poor selection of plates for the compilation; in part, because no critical scores are provided That is, no information is given by the compilers of the test as to the number of plates likely to be failed by subjects whose color perception is normal or of the number likely to be passed by those whose color perception is defective

In this report of our experience with the compilation administered as one of a battery of color tests given to a large group of subjects having normal, low normal or defective color vision of varying degrees of defect, we plan to show that this compilation of plates, even when properly administered under the quality of illumination accepted as standard for color testing,<sup>2</sup> is inadequate to detect with reasonable accuracy the presence of defective color vision On the constructive side, we shall present a selection of 18 plates of this compilation which, when the test is properly administered, is adequate to screen persons with even minor degrees of defective red-green vision from those whose color vision is within normal limits

As previously reported, our general procedure was to administer a large battery of color tests, both laboratory and clinical in type On the basis of the composite picture obtained, we classified the color vision of each subject under the following categories normal, low normal, low discrimination sufficient to amount to a color defect, anomalous trichromasy (protanomaly, deuteranomaly and tritanomaly) and dichromasy (protanopia, deuteranopia and tritanopia<sup>3</sup>) A description of the color vision typified by these terms has already been reported<sup>4</sup> Our data thus permit us to evaluate each test of the battery as a diagnostic or screening medium, and as a medium for the differential classification of the type and extent of the color vision defect

It is not our intention to present here a detailed analysis of the responses to each plate of the American Optical Company's compilation made by subjects representing each of the types of defective color vision, as we did for the Ishihara and Rabkin tests There are no specific plates

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2 Hardy, L H Standard Illuminants in Relation to Color-Testing Procedures, Arch Ophth **34** 278 (Oct) 1945

3 We have had the opportunity to study too few cases of tritanomaly and tritanopia to warrant their inclusion in the present study The experimental subjects reported on here have predominantly defective red-green vision

4 Hardy, L H, Rand, G, and Rittler, M C Color Vision and Recent Developments in Color Vision Testing, Arch Ophth **35** 603 (June) 1946

in this compilation designed to analyze type of defect. We plan merely to show the distribution of errors made on the compilation for 365 subjects whom we judged on the basis of our battery of tests to have normal color vision and for 117 subjects similarly judged to have defective red-green vision. Our method of determining whether the color vision fell within normal limits has already been described.<sup>5</sup> The subjects tested were not selected on the basis of any statistical survey. They included patients referred to us by ophthalmologists, men rejected by the armed forces because of defective color vision and subjects obtained from some of the New York city high schools and from the Vanderbilt Clinic. Only the 40 plates designed to test literate subjects were scored. The demonstration plates (25, 26 and 46) and the "path" plates for illiterates (35, 36 and 45) were not included. For all testing the book was placed on the rack of the Macbeth easel lamp. This equipment, which was designed to furnish standard conditions for testing color blindness with pseudoisochromatic plates, provides 45 foot candles of illumination, the quality of which is the closest approximation to that of ICI Illuminant C commercially available.<sup>2</sup> The light fell on the test at an angle of 45 degrees, the viewing angle was normal, or 90 degrees, and the testing distance was approximately 30 inches (75 cm.)

#### THE FORTY PLATE SERIES

Results for the 40 plate series are given in figure 1. The data for the 365 subjects judged as having normal color vision are presented at the left of the chart, as rectangles in outline, the data for the 117 subjects with defective color vision, at the right of the chart, as black rectangles. The number of plates failed (error score), in increasing groups of 2, is plotted on the horizontal coordinate, and the percentage of subjects failing each group, on the vertical coordinate.

*Normal Color Vision*—As can be seen in figure 1, only 12.5 per cent of subjects with normal color vision failed none of the plates or only 1, 46 per cent failed 6 or more plates, the maximum number of plates failed was 17. Rarely was there complete failure to see a digit, as occurs frequently when color vision is defective. Rather, the usual type of error was a misreading of digits due to lack of careful scrutiny, as 48 for 43 (plate 2), a misreading of Stilling digits of German formation, as 25 for 75 (plate 30), the reading of the digits supposed to be invisible to persons with normal color sense (plates 33 and 34), or the partial misreading of a digit of the Ishihara plates, as 20 for 29 (plate 11). It should be noted that the printing of those sections of the digit supposed to be seen only when red-green perception is defective appears in stronger

<sup>5</sup> Hardy, Rand and Rittler,<sup>1c</sup> p. 257

coloration than in the original plates. This is particularly true of the green-blue and blue portions of these digits. There is, therefore, a greater incentive for the normal subject to read them, or parts of them, as reproduced by the American Optical Company than as presented in the original Ishihara test.

It may seem strange to one who has not had a wide experience in administering this compilation to a large unselected group, varying in intelligence and interest, that so many errors of these types can be made by persons with normal color vision. This, however, has been the general experience of persons who have administered it in the military services, in industry and in schools. The compilation is definitely faulty.

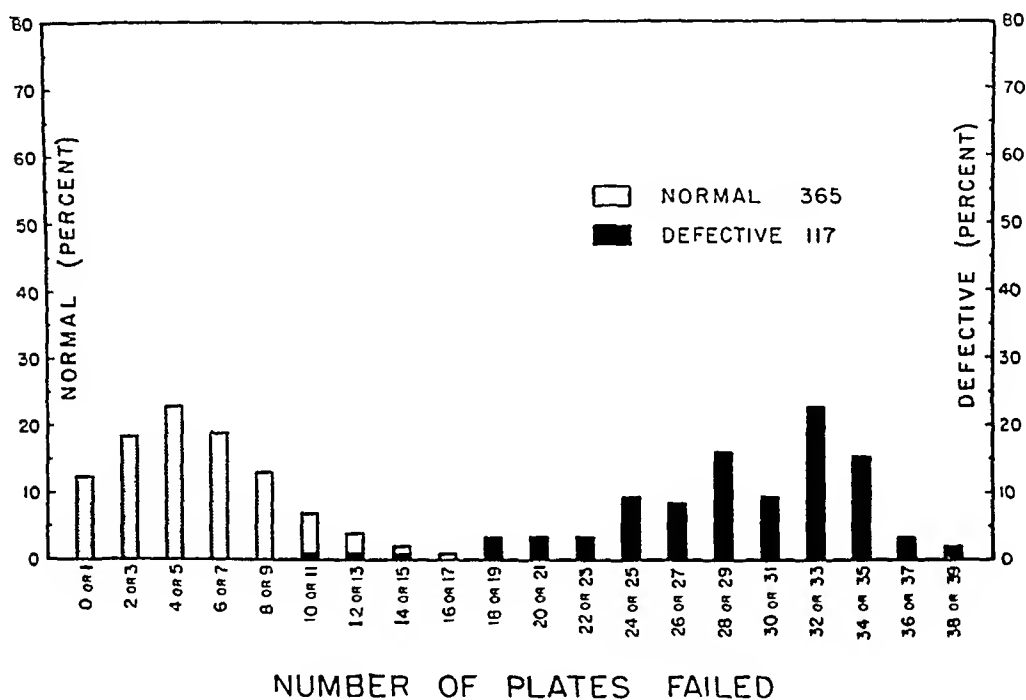


Fig 1—Results for the 40 plate compilation of the American Optical Company's pseudoisochromatic plates

in its inclusion of so many plates subject to misreading because of factors other than defective color vision.

*Defective Color Vision*—As can be seen in figure 1, subjects whose color vision was diagnosed as defective on the basis of our battery of tests failed as few as 10, and as many as 39, of the 40 plates used.

In brief, there is a range of 10 to 17 plates failed, which includes the error scores of some whose color vision was normal and some whose color vision was defective. Diagnosis on this compilation, therefore, is not possible when error scores occur within this range. In other words, no critical score can be established for this compilation which will differentiate between normal and defective color performance.

## THE EIGHTEEN PLATE SERIES

The problem, however, cannot be abandoned at this point. This test must, if at all possible, be made to do the work, since, as stated earlier, it is the only one worth considering which is commercially available at the present time. We feel that the problem can be met fairly satisfactorily by a selection of 18 plates from the American Optical Company's compilation. In selecting each plate we were not guided solely by statistical criteria. Our aim was simply to select a series of plates that would yield a critical score for normal and defective red-green vision. In general, we discarded as far as possible those plates on which insignificant errors were made, owing to factors other than defective color perception. At the same time, we needed to retain some plates which were failed by subjects whose defect in color vision was mild in degree even if these plates were occasionally misread by members of the normal group. In other words, we could not sacrifice the sensitivity of the series to detect minor degrees of defective color perception in the interest of securing a perfect response from all whose color vision is within normal limits. Also, we wished to include some plates failed by persons whose defect in color vision was marked. These considerations barred us from searching for plates passed by all the normal group and failed by all the group with defective color vision. Further, attention had to be given to excluding plates which vary greatly from copy to copy of the compilation. For this reason, plates 39, 40, 43 and 44 were rejected from our selection. Fundamentally, the selection was a trial and error procedure, being adjusted and readjusted according to the responses given chiefly by those normal subjects who failed many plates and by those subjects with defective color vision who failed few plates.

Our final selection includes plates 3, 4, 5, 6, 8, 9, 12, 13, 16, 17, 19, 20, 21, 23, 27, 29, 41 and 42. The results are shown in figure 2 for 365 subjects whose color vision we judged to be within normal limits and for 150 subjects whose color vision we judged to be defective. As in figure 1, the data for the normal group are presented at the left of the chart as rectangles in outline, the data for the group with defective color vision, at the right, as black rectangles. The number of plates failed (error score) is plotted on the horizontal coordinate, and the percentage of cases failing each successive number of plates, on the vertical coordinate.

*Normal Color Vision*—As can be seen in figure 2, 93 per cent of the subjects we judged on the basis of our battery of color tests to have normal color vision failed none of the 18 plates, or only 1, 4 per cent failed 2 plates, 2 per cent failed 3 plates, and 1 per cent failed 4 plates.

*Defective Color Vision*—All subjects we judged on the basis of our battery of color tests to have defective red-green vision failed 5 or more

of the 18 plates, and 2 per cent failed all the plates, the number of plates failed most frequently was 15 and 16, 80 per cent failed 11 or more plates. No subjects with dichromasy in our group failed fewer than 12 plates, and subjects with anomalous trichromasy whose defect was medium or marked failed from 9 to 17 plates. Thus, error scores cannot be considered as indicating the degree or extent of color deficiency, except within rough limits.

The value of this 18 plate selection has been tested by us for two years in color vision screening in schools and in other surveys as well as by a number of ophthalmologists connected with testing for civilian aviation. It has rendered good service and so far has given satisfactory information. We feel confident in recommending this selection to meet

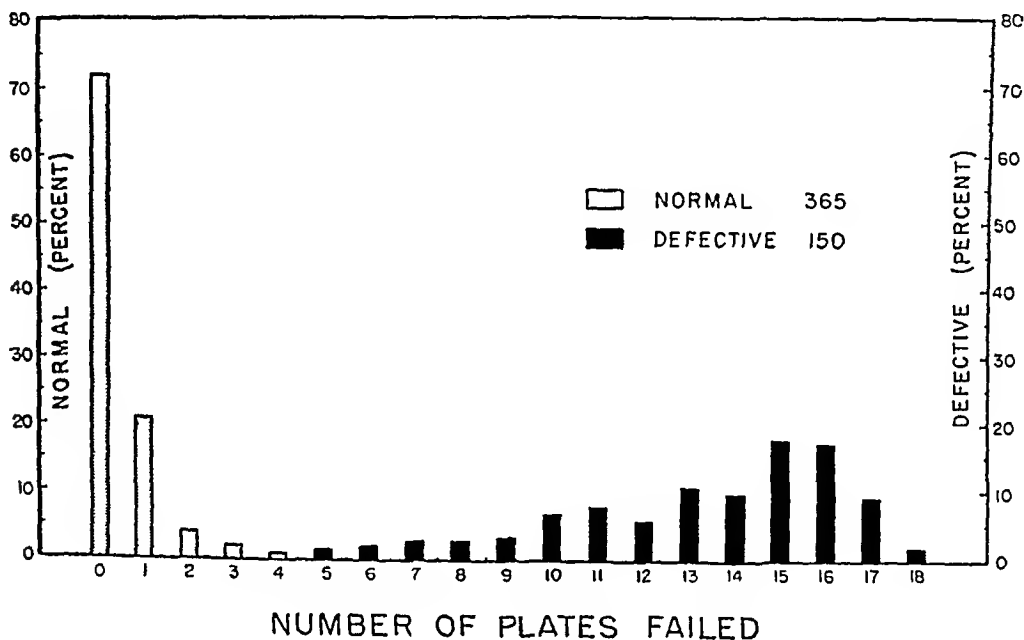


Fig 2—Results for the 18 plate selection from the American Optical Company's pseudoisochromatic plates

the present need for a test adequate to separate persons with normal from persons with defective red-green vision. This recommendation is contingent on the test being administered under the standard source of illumination.<sup>5a</sup>

The critical importance of illumination cannot be too strongly stressed in the use of any test designed to screen out persons with defective color vision. Merely "natural daylight" will not do. It is far too variable in quantity and quality to provide a standard test situation. For example,

<sup>5a</sup> Since this manuscript was submitted, the American Optical Company, with the approval of the Inter-Society Color Council, has issued a revised (18 plate) edition of Pseudo-Isochromatic Plates for Testing Color Perception, which follows the suggestions and instructions included in this report.



if the amount of light is too low, the error scores of some subjects with normal color vision will lie above the critical borderline. If the light is too blue, as when reflected from north sky or from snow, again some normal subjects will have an incorrectly high error score. This is mainly because the bluish digits of the Ishihara plates (those usually seen only when red-green vision is deficient) are enhanced in coloration and are, therefore, often responded to in whole or in part by the normal subject. On the other hand, if the illumination is too yellow, as in direct sunlight or illumination by incandescent lamps, the reverse situation holds. That is, these bluish digits are rendered less pronounced, sufficiently so that many subjects whose defect in color vision is mild give the correct response and thus lower their error score sufficiently to cross the boundary line into the region of normal error score. The effect of this last type of faulty illumination has already been reported<sup>6</sup>.

In conclusion, we wish to repeat that the 18 plate selection is intended for screening purposes only. It is neither qualitative nor quantitative, that is, it does not classify the type of deficiency in red-green vision or, except for the extremes of error score, the degree of deficiency. It should be pointed out again that no provision is made for detecting the rare forms of defective blue-yellow vision.

Appended is a copy of the instruction sheet we have prepared for those who may be interested in utilizing this 18 plate selection as a screening test for defective red-green vision.

**Instructions for Utilizing 18 of the American Optical Company's  
Pseudo-Isochromatic Plates for Testing Color Perception,  
as a Screening Test for Defective Red-Green Vision**

LEGRAND H. HARDY, M.D., GERTRUDE RAND, Ph.D., and  
M. CATHERINE RITTLER, B.A.

**Source of Illumination.** The Macbeth Easel Lamp. This can be purchased from Macbeth Daylighting Co., 227 W. 17th St., New York 11, New York, for \$20.

**Test Material.** A selected series from Pseudo-Isochromatic Plates for Testing Color Perception, American Optical Co., 1940. The following plates are used: No. 25 for demonstration, Nos. 3, 4, 5, 6, 8, 9, 12, 13, 16, 17, 19, 20, 21, 23, 27, 29, 41 and 42 for testing. Other plates are to be covered with a sheet of black paper.

**Instructions.** The subject should be seated with his eyes about 30 inches from the test book in position on the rack of the lamp. He is shown plate no. 25 (a red 12 on a blue background, a malingering test) and instructed to read the number or numbers on this and the following charts. The examiner allows for response about 2 sec. per plate. No further instructions are to be given and no questions asked. The subject is not allowed to trace the patterns or touch the test plates.

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6 Hardy, L. H., Rand, G., and Rittler, M. C. Effect of Quality of Illumination on the Results of the Ishihara Test, *Arch. Ophth.* 36:685 (Dec.) 1946.

Responses should be immediate (within 2 sec) Hesitant or studied responses are viewed with suspicion Responses are to be entered on a score sheet similar to that given below Number of plates failed is the subject's error score

Score Sheet			Date		
Name					
Plate No	Normal Response	Subject's Response	Plate No	Normal Response	Subject's Response
3	56	_____	17	25	_____
4	27	_____	19	5	_____
5	8	_____	20	3	_____
6	6	_____	21	97	_____
8	42	_____	23	56	_____
9	56	_____	27	89	_____
12	57	_____	29	86	_____
13	86	_____	41	15	_____
16	9	_____	42	74	_____
Total errors		_____			

Interpretation of Error Score Incorrect response to 4 or less plates indicates normal color vision, incorrect response to 5 or more plates indicates defective red-green vision

Limitations of Test This interpretation of error score holds only when the test is administered under the standard source of illumination The test is for screening purposes only It is neither qualitative nor quantitative—that is, it does not classify type of red-green defect, or the amount of defect No provision is made for detecting defective blue-yellow vision

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# TRACHOMA

## A Possible Carrier State

MARTIN BODIAN, M D \*

BROOKLYN

TRACHOMA is one of the most widely spread diseases in the world. It may be a definite threat to the American soldier as a result of continued exposure in the Asiatic countries. It is conservatively reported that in China the disease has an incidence of about 25 per cent, implicating about 100,000,000 people<sup>1</sup>. In 1928 Japan was reported to have 17 per cent of its conscripts infected<sup>2</sup>. MacCallan<sup>3</sup> found there was heavy seeding of trachoma throughout the British Colonial Empire. It was especially prevalent in the Asiatic countries. The Fiji Islands are a known endemic area of trachoma. The local health authorities find it a definite epidemiologic problem. Reliable public health figures have never been available because of the lack of trained personnel to conduct an adequate survey<sup>4</sup>.

My interest developed during the medical examination of a group of natives employed by the United States Army stationed at Fiji. Studies were instituted to determine the incidence of trachoma among the natives and the spread of the disease to American troops.

The purpose of this paper is to present these observations and (1) to show the morbidity rate of trachoma among natives working at an American Army base in Fiji, (2) to demonstrate the presence, if any, of trachoma in troops stationed in an endemic area for long periods, and (3) to advance the hypothesis of a possible carrier state.

## METHODS

Two groups of subjects were studied. One consisted of 100 natives employed at an American Army base in Fiji, the other, of 50 American soldiers stationed at the same base for a year or more. Both groups were selected at random from different parts of the camp.

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\*Formerly Captain, Medical Corps, Army of the United States

1 Miyashita, S. Trachom in Japan und den grenzgebeiten Chinas, Internat Cong Ophth 3 169, 1929

2 Kusama, H. Prevalence of Trachoma and of Its Preventive Measures in Japan, Japanese M World 8 154 (June) 1928, cited, Bull Hyg 4 264 (March) 1929

3 MacCallan, A. F. Trachoma in the British Colonial Empire, Brit J Ophth 18 625 (Nov) 1934

4 Personal communication to the author

Clinical data were obtained from all subjects to include age, sex, general health, immediate living conditions, length of stay in Fiji, location of permanent residence, family history of ocular trouble, if obtainable, and finally, individual history of ocular disease

All eyes were examined grossly and with the aid of a condensing lens and loupe with a  $2\frac{1}{2}$  magnification. The external pathologic changes in the eye were recorded on a total of 300 eyes of the 150 subjects studied. Epithelial scrapings were taken from the tarsal conjunctiva of the upper lid of both eyes of each subject. The specimens, spread thinly on glass slides, were fixed with methyl alcohol. Dilute Giemsa stain, adjusted to a  $pH$  of 7.2, was then applied for twenty-four hours. When the specimens stained poorly, repeat smears were made until easily readable specimens were obtained. The slides were then carefully examined for Prowazek-Halberstadter inclusions at a magnification of 950.

Fifteen patients were followed at monthly intervals over a four month period for beginning external ocular disease. One patient was examined in the same manner at weekly intervals over this period. In this case epithelial scrapings were studied for inclusion bodies after each examination.

*Personal Data and Histories*—Native Subjects. The ages of this group ranged from 14 to 60 years, with a mean average of 24.8 years. Twelve of these subjects were females. All stated that they were in good general health. They attended their jobs at the post as laborers with regularity. The great majority lived in small wooden shacks or thatched huts. Ordinary hygienic measures, such as toilet facilities, use of individual towels and fly control, were practically nonexistent. The fact that practically all the subjects harbored a museum variety of intestinal parasites attested to the lack of sanitation among these people. No natives lived within the Army base confines. All were born in Fiji. In addition to the aboriginal Melanesians of this group, there were East Indians, Melanesian-Caucasian half-castes and Rotumans<sup>5</sup>. Because of language difficulties and low educational standards, family histories were considered entirely unreliable. For this reason, they were excluded from this report.

Twenty-five of the native subjects stated that they had had symptoms suggesting inflammation of the conjunctiva. Among these complaints were irritation, redness, photophobia and discharge. Six of these subjects complained of some of these symptoms at the time of examination. The duration of symptoms in the entire group varied from two days to two years. None of this group had received any specific treatment.

*American Subjects*. The average age of this group was 27.8 years, with a range of 19 to 47 years. All were men and in robust health. Their homes were located throughout the United States, with no locality predominating. Strictly enforced military sanitation prevailed at their

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<sup>5</sup> Rotumans are a Polynesian-Chinese admixture derived from Rotuma, an island on the periphery of the Fiji group.

garrison station in Fiji. All had been at this base for from twelve to thirty-seven months, with an average stay of 24.8 months. None knew of any chronic inflammatory disease of the eyes in their families. All stated that they had never had trachoma or any condition suggestive of it.

Military regulation prohibits our men from consorting with the natives in this area. In general this ruling was complied with.

*Clinical Ocular Findings*—Native Subjects. Twenty-two of the 100 natives, or 22 per cent, showed evidence of active trachoma. This consisted of redness, thickening and definite scarring or follicle formation of the tarsal conjunctiva, together with infiltration and vasculariza-

TABLE 1—Summary of Clinical Data on Patients Showing Evidence of Trachoma

Case No.	Age, Yr.	Duration of Symptoms	Conjunctival Changes			Follicles §	Pannus ¶	Entropion, Trichiasis
			Thickening *	Scarring †	Hyperemia ‡			
7	48	2 yr	+	+	+	—	+	—
10	30	2 yr	++	++	++	—	++	—
12	34	2 yr	++	++	++	—	++	—
13	19	None	+	+	++	—	+	—
17	19	None	++	++	++	—	+	—
18	39	3 wk	++	+	+	—	+	—
30	23	2 yr	+++	++	+++	—	+	—
52	14	None	+	+	++	—	+	—
53	21	None	+	++	+	—	+	—
55	43	2 yr	+	++	+	—	+	—
57	22	None	+	+	+	—	++	—
60	18	None	+	—	+	—	+	—
61	35	1 wk	+	+++	+	—	++	Entropion
62	28	1 yr	+	++	++	—	++	—
82	30	2 wk	—	+	+	—	+	—
88	38	None	+	+	+	—	+	—
91	42	1 wk	+++	+++	+++	—	+++	Entropion, trichiasis
92	29	None	+	++	+	—	+	—
93	18	None	++	+	++	+	+	—
98	41	None	+	+	+	—	+	—
99	60	2 wk	++	++	++	—	++	Entropion
100	28	2 wk	+	+	+	—	+	—

\* Barely discernible heaping is indicated by +, uniform, early discernible thickening by ++, and marked thickening, with the closed lid overly convex, by +++.

† Scarring which is barely discernible and may require the aid of a loupe is indicated by +, scarring easily discernible grossly, by ++, and gross scarring, causing malformation of the lid, by +++.

‡ A mild, rose colored blush is indicated by +, a bright red conjunctiva but discrete vessels discernible, by ++, and a bright, beefy red conjunctiva, with individual vessels not made out, by +++.

§ The absence of conjunctival follicles is indicated by — a few scattered follicles are indicated by +.

¶ Vessels 2 to 3 mm in from the limbus are indicated by +, vessels 3 to 6 mm in from the limbus, by ++, and vessels more than 6 mm in from the limbus, by +++.

tion of the cornea. Each of the native patients with positive clinical evidence of trachoma had practically identical lesions in the two eyes. Most of these persons had trachoma stage III (table 1).

Twenty-six of the remaining 78 trachoma-free subjects showed conjunctival hyperemia. This was mild and bilateral in all patients. Particularly close scrutiny revealed no evidence of trachoma. Except for occasional pingueculae, pterygiums and the like, the eyes of the

remaining 52 persons seemed entirely normal on external examination. Six patients gave a history of ocular symptoms for six months or more. Five of these (83.3 per cent) had clinical evidences of trachoma. Seventy-five subjects had no symptoms referable to the eyes, yet 10 of these (13.3 per cent) had clinical trachoma (table 2).

**American Subjects.** None of the American soldiers had clinical trachoma. On the other hand, all but 6 of the men showed mild conjunctival hyperemia. The condition was always bilateral and was noted only on the palpebral portions. Occasional pingueculae and pterygia were also noted.

TABLE 2—*Relation of History of Ocular Inflammation to Clinical Evidence of Trachoma*

Length of History of Inflammation	Subjects with Clinical Trachoma	Trachoma Free Subjects	Total No. of Subjects	Percentage with Clinical Trachoma
More than 6 months	5	1	6	83.3
1 to 6 months	1	2	3	33.3
Less than 1 month	6	10	16	37.5
None	10	65	75	13.3
Total number	22	78	100	22.0

TABLE 3—*Distribution of Inclusion Bodies in One or Both Eyes in Patients with Microscopically Suggestive Evidence of Trachoma*

	Unilateral Inclusion Bodies		Bilateral Inclusion Bodies		Total	
	No. of Eyes	No. of Patients	No. of Eyes	No. of Patients	No. of Eyes	No. of Patients
Patients with trachoma	2	2	26	13	28	15
Patients free of trachoma	15	15	24	12	39	27
Total number	17	17	50	25	67	42

**Laboratory Findings.—Native Subjects.** For this study the natives fell into two convenient groups—those with trachoma and those who were free from trachoma. Fifteen of the 22 patients with clinical trachoma also showed Prowazek-Halberstadter inclusion bodies. Thirteen of these 15 patients showed these bodies in smears of material from both eyes. Two of the 15 patients exhibited these bodies in only one eye. Fifteen of 27 patients who were free of trachoma clinically showed the bodies in smears from one eye only, and 12 showed inclusions in smears from both eyes (table 3). Of the 22 trachomatous subjects, 68.2 per cent then, revealed inclusion bodies.

Of the remaining 78 subjects, 27, or 24.6 per cent, harbored inclusion bodies in one or both eyes. It is to be remembered that none of these 78 subjects had shown the least evidence of the disease. These

inclusion bodies were microscopically indistinguishable from those observed in smears from the trachomatous patients (figs 1 and 2)

When the two groups are considered together, one finds that of 100 natives, 42 exhibited Prowazek-Halberstadter inclusion bodies of the conjunctival epithelium (table 4)

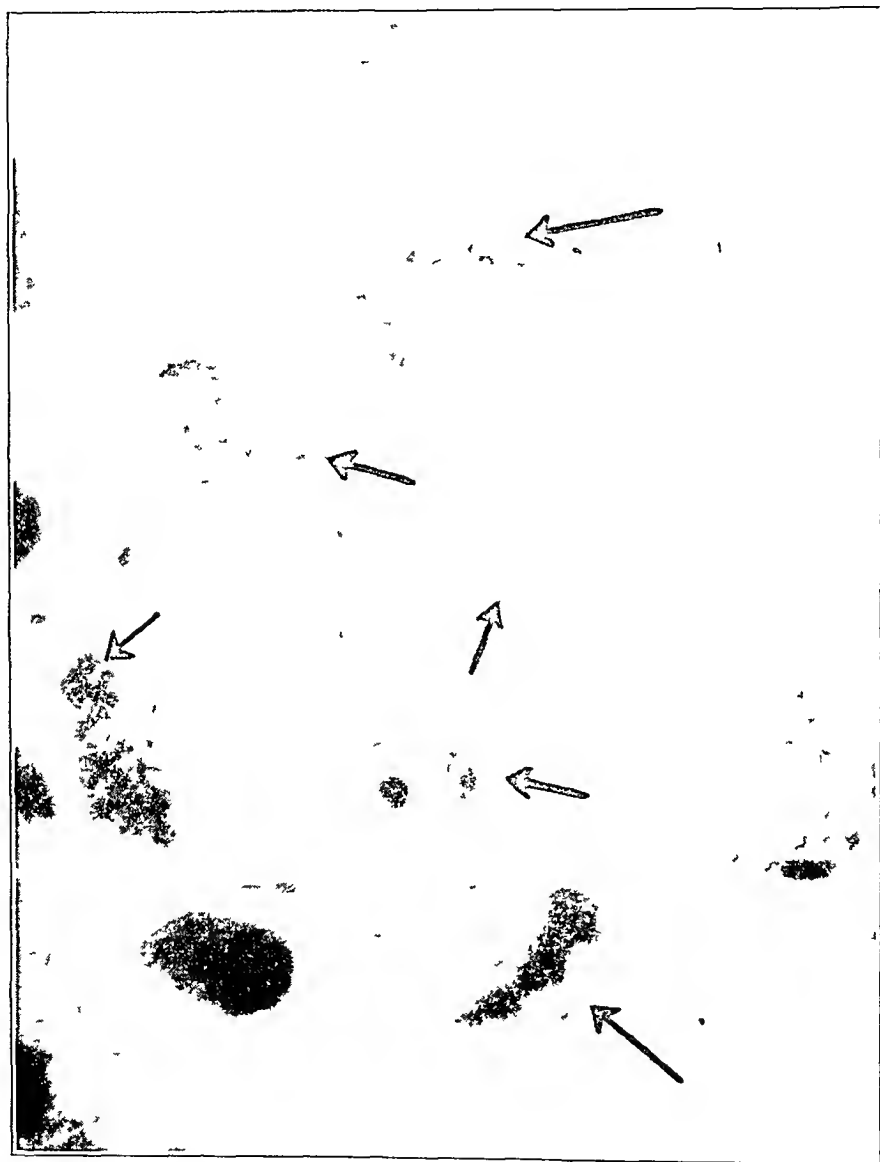


Fig 1—Photomicrograph (1,500 magnification) of conjunctival scrapings from the eye of a Fijian native with active trachoma. Arrows indicate inclusions in the epithelial cells in various phases of development

American Soldiers. Prolonged and careful search revealed no inclusion bodies of any description. Rarely a few isolated bacteria were noted. These showed no uniformity as to staining properties or morphologic characteristics.

*Follow-up Observations*—Fifteen of the 27 natives who harbored inclusion bodies and yet had no clinical disease were examined at monthly intervals. Signs of early cicatrization, follicle formation and corneal vascularization were searched for. These were persistently absent over a four months' period of observation.



Fig 2—Photomicrograph (1,500 magnification) of conjunctival scrapings from the eye of a Fijian native who showed no clinical evidence of trachoma, either past or present. Arrows indicate inclusion bodies in various phases of development. In no way were these inclusion bodies distinguishable from those observed in cases of clinical trachoma.

One native who showed the same changes as the natives in the preceding group was followed at weekly intervals for four months in



the same way Smears for inclusion bodies were examined at the same time Although the smears showed persistently heavy seeding, no clinical evidence of beginning trachoma could ever be detected

## COMMENT

*Clinical Trachoma in Fiji*—It was noted that 22 per cent of 100 natives working at an Army base in Fiji had clinical evidence of trachoma Although these natives had come from widely separated areas of the islands, they did not represent a completely random sample of the population The fact that they were able to be employed as laborers at an Army installation of limited size indicated that they were in good general health, fell into a definite age group, were not industrially blind and constituted a small sampling of the population The disparity in numbers of males to females in this study was also out of keeping with the general population In spite of these shortcom-

TABLE 4—*Number of Patients Showing Prowazek-Halberstadter Inclusion Bodies in Clinically Trachomatous and Nontrachomatous States*

Type of Patient	Number of Patients Showing Inclusion Bodies	Number of Patients Showing No Inclusion Bodies	Total Number of Patients	Percentage of All Patients Showing Inclusion Bodies
Trachomatous	15	7	22	68.2
Free from trachoma	27	51	78	34.6
Total	42	58	100	42.0

ings, it is believed that these findings give a suggestion of the general picture of trachoma in Fiji Extensive and thoroughgoing surveys are still awaited for this area

The incidence of trachoma of 22 per cent found in this study is of particular interest as compared with the consolidated statistics on American Indians made in 1938, which showed a rate of 20.2 per cent<sup>6</sup> Since that year the sulfonamide drugs have decreased that morbidity rate remarkably<sup>6</sup>

None of the subjects in the present series had received specific therapy for trachoma prior to this study Their primitive, agricultural mode of living has changed little in the past decade

*Trachoma Among American Troops*—On the basis of correspondence with a number of oculists on military service overseas, Thygeson<sup>8</sup> expressed the opinion that trachoma does not represent a serious

6 Forster, W. G., and McGibony, J. R. Trachoma, *Am J Ophth* **27** 1107 (Oct, pt 1) 1944

7 Footnote deleted by the author

8 Thygeson, P. Personal communication to the author, April 1945

military problem. My findings would tend to bear out the validity of this opinion.

Although a slit lamp was not available, I am in agreement with MacCallan's<sup>9</sup> statement that careful observation with a condensing lens and corneal loupe will disclose pannus formation. By this means early changes were made out at the limbus in trachomatous patients. These included distortion of the capillary loops, early vascularization beyond the limbus and corneal infiltrations. Our subjects who were free from trachoma showed none of these changes.

The high prevalence of conjunctival hyperemia among our troops has caused much speculation. It was seen in almost all American troops stationed in Fiji for over a year. Smears and bacterial cultures have failed uniformly to show any specific causative organism. Several other Army oculists stationed here found the same condition among their patients. Over a three year period none had ever found anything that resembled trachoma among these soldiers. Thousands of troops have been seen during this time in the various Army eye clinics in Fiji. Tropical sunlight, heavy exposure to dust and the prevalence of plant allergens may account for some of the conjunctival hyperemia.

The absence of inclusion bodies in the conjunctival scrapings would seem to confirm our clinical findings in regard to trachoma among our men.

*The "Carrier State"*—Recent papers by several of the leading world authorities on trachoma have made no mention of trachoma carriers.<sup>10</sup>

In the present series of cases, 27 of 78 subjects (34.6 per cent) who were free from trachoma had demonstrable conjunctival inclusion bodies. These bodies were indistinguishable from those seen in each of the cases of trachoma.

Two typical slides showing these inclusion bodies from the trachoma-free subjects were sent to the section on virology of the Eighteenth Army medical general laboratory. The staff reported that the smears were consistent with those seen in cases of trachoma.

From all available sources (civilian as well as military) there is excellent reason to believe that inclusion blennorrhoea, lymphogranuloma

9 MacCallan, A. F. Clinical Signs of Trachoma, *Rev. internat. du trachome* **11** 3 (Jan) 1934.

10 (a) MacCallan<sup>3</sup> (b) Forster and McGibony<sup>6</sup> (c) MacCallan<sup>9</sup> (d) Julianelle, L. A., and Smith, J. E. A Statistical Analysis of Clinical Trachoma, *Am. J. Ophth.* **26** 158 (Feb) 1943. (e) Thygeson, P. Viruses and Virus Diseases of the Eye, *Arch. Ophth.* **29** 285 (Feb), 488 (March), 635 (April) 1943, (f) Trachoma, in Piersol, G. M., Bortz, E. L., and others. *Cyclopedia of Medicine*, Philadelphia, F. A. Davis Company, 1935. (g) Lindner, K., in Berens, C. *The Eye and Its Diseases*, Philadelphia, W. B. Saunders Company, 1936.

venereum and psittacosis do not exist in this locality. The inclusion bodies of these diseases seem to be the only ones to be mistaken for trachoma bodies in the eye.<sup>10a</sup> The absence of these diseases and the prevalence of trachoma in this area support the opinion that the inclusions noted are derived from trachoma.

There is good reason to believe that the microscopic inclusions are Prowazek-Halberstadter corpuscles. The only other objects with which they could be confused are pigment granules or technical artefacts. We are convinced that they were neither. The usual conjunctival pigment, when present, consists of melanin. The tarsal conjunctiva is an unusual site for this pigment, and melanin was never seen grossly here in our patients. Microscopically, conjunctival melanin is seen as diffusely scattered, intracellular greenish granules (Giemsa stain), which do not form conglomerate masses similar to those of inclusion bodies and do not invade the nuclei of epithelial cells. The bodies we observed were always derived from the tarsal conjunctiva, tended to form characteristic morphologic groups, took a fairly pure blue stain (Giemsa) and occasionally were seen in the nuclei of the conjunctival cells. The morphologic conglomerations, such as "cape" formations and initial body groups, were identical with those described by Lindner and Thygeson in their various excellent articles on the subject. Extracellular elementary bodies were also noted in some instances.

From what has been said regarding the characteristics of the inclusions noted, I feel strongly that they were not technical artefacts. I examined every slide in this study. When, on occasion, a reasonable doubt existed, the slide was called negative for Prowazek-Halberstadter bodies. The fact that the virologists at the Eighteenth Army medical laboratory concurred in our belief that the inclusion bodies were consistent with those observed in cases of trachoma strengthens our feeling on the matter. The slides which they reviewed were taken from persons free of clinical ocular disease. Furthermore, all the slides in this study were treated with the same technic. The natives' slides showed many inclusion bodies, but not one of the Americans' did. This indicates, we feel, that the bodies noted were not technical artefacts.

In order to rule out a possible preclinical or incubation phase of trachoma, a follow-up study was instituted. Fifteen persons who were free from trachoma and who showed inclusion bodies were examined at monthly intervals for signs of beginning trachoma. Over a period of four months I was unable to detect the least evidence of scarring, follicle formation or corneal involvement. One subject was examined for inclusion bodies, as well as clinical signs, at weekly periods. Although his smears were repeatedly positive, no clinical

changes could be detected in a four month survey. Since the incubation period for trachoma is five to twelve days, we felt that these patients did not represent an incubation phase of the disease. The findings in these patients are consistent with a carrier state in trachoma and can be fully explained on this basis.

Broadhurst and associates<sup>11</sup> demonstrated a carrier state in patients with virus infection of the throat. Bodies of the same type which were found in the throat were also found in the eyes of 2 subjects. Carriers of the virus of other diseases, such as herpes, have been known to be asymptomatic over a period of years.<sup>12</sup> Trachoma is generally accepted to be a virus disease. My observations with respect to a carrier state in trachoma conform with those of workers on carrier states in other virus diseases.

It is interesting to speculate on the origin of the carrier state in our cases. MacCallan and others reported that trachoma typically begins imperceptibly and may go on to spontaneous cure.<sup>13</sup> It may well be that our "carriers" represent instances of just such a state.

Without a virology laboratory or suitable experimental animals at my disposal, I have been unable to demonstrate the transmissibility or pathogenicity of the bodies in these "carriers." Until this is done, a true carrier state in trachoma will not be fully proved. It is hoped that these important studies will soon be under way.

#### SUMMARY AND CONCLUSIONS

Of 100 natives working at an American Army base in Fiji, 22, or 22 per cent, had clinical evidence of active trachoma.

Typical Prowazek-Halberstadter inclusion bodies were seen in the conjunctival epithelial scrapings of 15 of these patients, an incidence of 68.2 per cent.

Evidence is presented which suggests the existence of a carrier state in trachoma. Seventy-eight native subjects employed by the American Army showed no evidence of clinical trachoma. Of these, 27, or 34.6 per cent, had inclusion bodies in the conjunctival epithelial scrapings morphologically indistinguishable from those observed in frankly trachomatous patients. Transmissibility and pathogenicity of the virus of trachoma from these patients still await demonstration.

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11 Broadhurst, J., Liming, R., MacLean, E., and Taylor, I. Cytoplasmic Inclusion Bodies in Human Throat, *J Infect Dis* **58** 134 (March-April) 1936.

12 Broadhurst, J., MacLean, E., and Taylor, I. Increased Incidence of Cytoplasmic Virus Bodies in Human Throats in New York City Area, *J Infect Dis* **73** 195 (Nov-Dec) 1943.

13 MacCallan, A. F. Trachomatous Conjunctivitis. Its Surgery and Pathology (Hunterian Lecture), *Lancet* **1** 215 (Jan 25) 1936.

Of 100 native subjects studied, both those with and those without clinical trachoma, 42, or 42 per cent, harbored Prowazek-Halberstadter inclusions in the conjunctival epithelium.

One hundred eyes of 50 American soldiers who have been based in an area endemic for trachoma (Fiji) for one to three years were examined for evidence of the disease. Clinical and laboratory evidence indicated the absence of trachomatous infection among these men.

With proper sanitation and segregation of the soldier from the native population, trachoma would not seem to present a military problem.

Technician Fourth Grade Hugh P. Earle, Medical Department, Army of the United States, prepared the laboratory material used in this report.

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# TREATMENT OF LINDAU'S DISEASE

Report of a Case

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LINDAU'S disease is an angiomatosis of the central nervous system characterized by the occurrence of single or multiple hemangioblastomas in the cerebellum, brain stem or spinal cord, associated with angiomatosis of the retina (von Hippel's disease). In addition, there are present various congenital lesions of other organs, such as cystic disease of the kidneys and pancreas. Lindau found that the retinal lesions made their appearance at the average age of 25, while cerebellar symptoms did not become manifest until about fourteen years later, when partial blindness had usually set in. Cox and Trumble<sup>1</sup> pointed out that autopsy of patients with this disease has frequently revealed a hemangioma of the spinal cord which clinically had shown no evidence of its presence. The case to be described is unique in that compression of the cord by a vascular tumor was the primary and outstanding feature and only later was a typical, nonsymptomatic retinal angioma discovered on routine ophthalmoscopic examination.

As in the case of many other tumors, a controversy exists in the treatment of von Hippel's disease, some preferring electrosurgical measures and others irradiation. The successful destruction of retinal angiomas by diathermy puncture was first described by Weve,<sup>2</sup> of the

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1 Cox, L B, and Trumble, H C. Tumors and Malformations of Blood Vessels of Brain and Spinal Cord, M J Australia **2** 308-319 (Aug 26) 1939

2 Weve, H. Bowman Lecture. On Diathermy in Ophthalmic Practice, Tr Ophth Soc U Kingdom **59** 43-80, 1939

Netherlands, in 1939 and was first performed in this country by Lewis<sup>3</sup> in 1942. Guyton and McGovern,<sup>4</sup> in 1943, obliterated multiple angiomatous lesions of the retina, which had been progressing in spite of roentgen irradiations, with 1,500 r to each eye. In view of these favorable reports, and because the retinal angioma, in an early stage, was situated near the equator, readily accessible to diathermy puncture, we employed this method of treatment.

#### REPORT OF CASE

R. C. J., a Negro soldier aged 27, in November 1943 noted the gradual onset of weakness of the right leg with dragging of the toes of the right foot and some difficulty in starting the urinary stream. During the next month he complained of shooting pains up and down the spine, and the weakness of his right leg progressed so that he became unable to climb stairs. Examination revealed spasticity of the right leg in walking. The deep reflexes of the right upper extremity and of both lower extremities were hyperactive, with bilateral ankle clonus and absence of the abdominal and cremasteric reflexes. The plantar response, which was elicited bilaterally, consisted in fanning of the smaller toes without dorsiflexion of the great toes. There was pronounced weakness of the right lower extremity with some atrophy of the muscles of both the thigh and the calf and a conspicuous increase in their tone. The left leg was only slightly weak and spastic, with no atrophy. A band of hypalgesia was present over the ninth and tenth dorsal dermatomes on the right side, with minimal hypalgesia of the left leg to about the level of the thigh. Spinal puncture revealed a positive reaction to the Queckenstedt test and a total protein content of 800 mg per hundred cubic centimeters. A roentgenogram of the spinal column showed no evidence of a pathologic process, but a myelogram taken with "pantopaque" (a mixture of ethyl esters of isomeric iodophenyl undecylic acids) showed a filling defect from the eighth to the eleventh dorsal segment and a slight defect as high as the first dorsal segment. Routine laboratory tests, including blood counts, urinalysis and a Wassermann test of the blood, revealed nothing abnormal.

Although the presence of hyperactive reflexes in the right upper extremity could not be explained, the patient was thought to have a tumor of the cord, and on Feb. 26, 1945 a laminectomy was done from the ninth dorsal to the first lumbar vertebra. A graphic description by Major G. L. Maltby of the observations at operation follows:

"On exposure of the cord, a most interesting and amazing picture came into view. The dorsum of the cord was almost completely covered with numerous vermiform, dilated blood vessels. On the right side of the posterior portion of the cord, at a point about the level of the eleventh dorsal vertebra, there was a pinkish, flesh-colored tumor nodule, about  $\frac{1}{4}$  inch (6 mm) in diameter. Several of the vessels seemed to enter this tumor mass and others to pass around it. At the upper end of the dural opening a great mass of dilated veins seemed to become more profuse and resembled tightly coiled ringlets of curled hairs."

Excision of this great network of vessels was deemed inadvisable, and a biopsy specimen was taken from the small tumor nodule. Major Webb Haymaker, of the Army Institute of Pathology, gave the following description of the specimen (fig. 1):

3 Lewis, P. M., *Angiomatosis Retinae: Successful Treatment (Puncture Diathermy) in One Case*, *Arch. Ophth.* **30**: 350-354 (Aug.) 1943.

4 Guyton, J. S., and McGovern, F. H., *Diathermy Coagulation in Treatment of Angiomatosis Retinae: Case*, *Am. J. Ophth.* **26**: 675-684 (July) 1943.

"The specimen consists of only a few small fragments of tissue. The tumor is composed of a number of small blood spaces, lined with endothelium and supported by polymorphous cells with highly chromatic, spherical, oval or irregularly elongated nuclei and abundant, homogeneous cytoplasm with ill defined borders. Within the

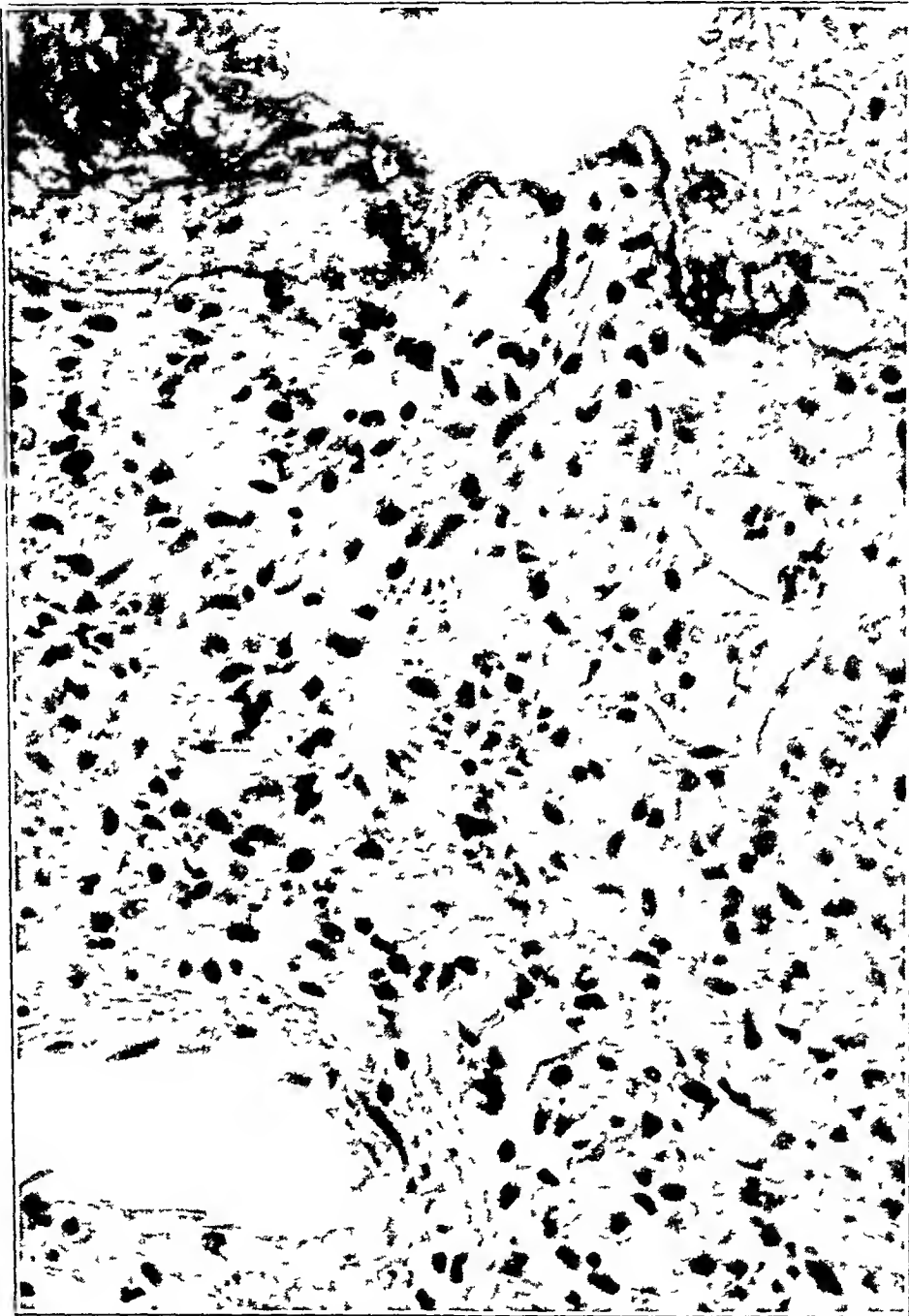


Fig 1—Photomicrograph of the tumor of the spinal cord. United States Army Medical Museum, neg no 95103,  $\times 400$

tumor proper there are also a few large vessels having the appearance of veins. The adjacent portion of the spinal cord is entirely necrotic and is being invaded *en masse* by the tumor. The appearance of the tumor conforms to that of a sclerosing hemangioma."



After roentgen therapy (5,400 r to the lumbodorsal portion of the spine), the patient was discharged from the Army to a veterans administration hospital, on June 19, 1945. Examination here revealed hyperreflexia of the upper extremities and persistence of the spastic paraplegia, although the patient stated that his hands were stronger and the control of urine better. There was no family history of blindness or disease of the central nervous system. Routine ophthalmologic examination revealed vision of 20/20 in each eye, and the patient had no ocular complaints. The right eye was normal, but in the fundus of the left eye the superior temporal artery and vein were greatly dilated and tortuous, with beading of the artery

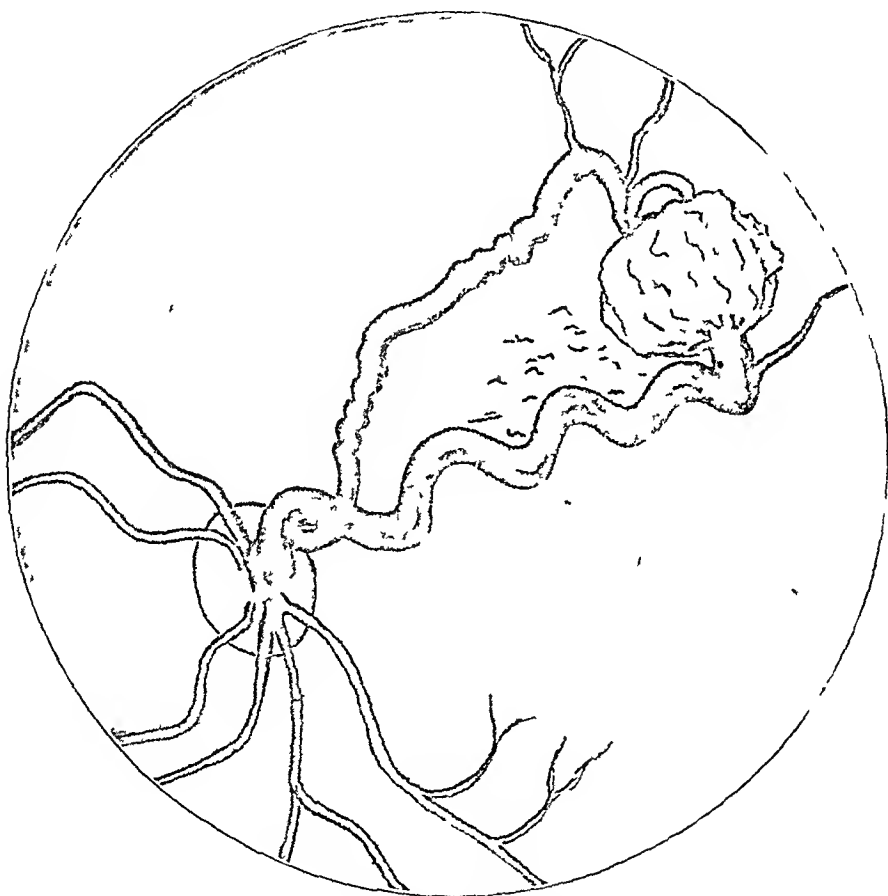


Fig 2—Appearance of the fundus of the left eye

When the pupils were dilated with 5 per cent solution of encatropine ("euphthalmine") hydrochloride, these vessels could be seen to end far in the periphery of the retina near the ora serrata, on either side of an almost circular reddish striated mass, measuring 1.5 disk diameters. Below this slightly elevated mass were a few horizontal yellow streaks of exudate in the retina. The macula was normal (fig 2).

**Operation and Course**—Since von Hippel's disease ultimately leads to blindness, electrocoagulation of the retinal angioma was performed on August 6, with retrobulbar anesthesia induced with 1 per cent procaine hydrochloride. A conjunctival flap was made superiorly, and the upper half of the globe was exposed by dividing the tendon of the superior rectus muscle. The Walker diathermy apparatus

was used, a single needle, consisting of a fine stylet wire guarded with a piece of glass capillary tubing in the plastic holder, being employed. A trial puncture of the sclera was made with the diathermy needle at the approximate position of the angioma. The small white lesion so produced in the retina was readily visible with the ophthalmoscope  $\frac{1}{3}$  disk diameter above and nasal to the angioma. With this spot as a guiding point, ten punctures were made into the tumor, the coagulated portions turning white. After this procedure only the upper surface of the lower quarter of the angioma remained pink. The bubbles of vitreous which formed elevated the two large vessels arising from the tumor and thus prevented their destruction. There was no hemorrhage, and the conjunctiva was closed after resuturing the severed rectus muscle. The postoperative reaction in the eye was mild. On the third day the untreated eye was uncovered, and on the seventh day both eyes were uncovered and the patient allowed out of bed in a wheel chair. The left eye was atropinized for three weeks. A month later severe acute pyelonephritis developed, which was controlled only with a cystotomy and intensive treatment with sulfadiazine and penicillin. The patient has been bedridden since, with recurrent exacerbations of pyelonephritis.

Examination on June 6, 1946 revealed no abnormality in the right eye. In the left eye the superior temporal vein had shrunk to the same caliber as the inferior temporal vein. Near the site of the angioma it became hairlike and almost invisible. The superior temporal artery was slightly larger than the inferior temporal artery and was still beaded. The upper half of the lesion was replaced with white scar tissue, the lower half was still pink but was no longer striated or elevated, and the yellow streaks in the retina near it were absent. Visual acuity in each eye was unchanged. Neurologic examination revealed an increase in the spastic paraplegia with incontinence of feces. Both upper extremities were weak, with hyperactive reflexes. The right arm was weaker than the left and gave a positive Hoffmann response.

#### COMMENT

In their pathologic study of vascular lesions of the spinal cord, Turner and Kernohan (1941)<sup>5</sup> classified hemangioma and hemangioblastoma as vascular neoplasms and stated that the difference between them was one of degree, "the latter appearing as a more cellular and microscopically more active tumor than the former." They added that these vascular tumors are rarely architecturally pure and that intermediate forms are frequently seen. Bailey and Ford (1942)<sup>6</sup> used the terms hemangioma and hemangioblastoma interchangeably, pointing out that the former term is the one more often employed by general pathologists for vascular tumors of the skin and other viscera, whereas the latter term is used particularly by neuropathologists to apply to vascular tumors of the brain. Since the lesion of angiomatosis retinae is a hemangioblastoma of the cerebral part of the retina, it is inconceivable that a similarly rare vascular tumor elsewhere in the central

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5 Turner, O. A., and Kernohan, J. W. Vascular Malformations and Vascular Tumors Involving the Spinal Cord, *Arch Neurol & Psychiat* **46** 444-463 (Sept) 1941.

6 Bailey, O. T., and Ford, R. Sclerosing Hemangiomas of the Central Nervous System, *Am J Path* **18** 1-27 (Jan) 1942.

nervous system would have a different ultimate histologic structure. Indeed, we should feel almost justified in making the diagnosis of angioblastoma of the cord on the basis of the excellent description of the tumor as seen at operation, which so closely resembles the description and photographs of the angioblastoma of the spinal cord seen at necropsy in the case of Lindau's disease described by Davison, Brock and Dyke.<sup>7</sup>

It is impossible to make a diagnosis of the complete Lindau pathologic complex in this case until autopsy is performed, for only then can the other congenital visceral anomalies be disclosed. Craig, Wagener and Kernohan<sup>8</sup> expressed the opinion, however, that one is justified in making a diagnosis of Lindau's disease on finding an angiomatosis retinae together with a surgically proved cerebellar hemangioblastoma. This view is generally accepted. Similarly, we feel that the diagnosis of Lindau's disease is established in our case by the presence of von Hippel's disease in association with a surgically verified hemangioma (hemangioblastoma) of the spinal cord. In a review of the literature through June 1939, MacDonald<sup>9</sup> found only 10 cases of Lindau's disease in which the diagnosis had been verified by operation during life. MacNab,<sup>10</sup> in 1941, reported another case, and in the same year Craig and associates<sup>8</sup> reported 4 more. Our case can now be added to this list and is the first to be verified by laminectomy and the observation of a vascular tumor of the spinal cord. Since the aim of every surgeon is to make a preoperative pathologic diagnosis, it is accordingly recommended that the periphery of the fundus be examined with mydriasis in all cases of suspected tumor of the cord, just as Cushing and Bailey<sup>11</sup> advised in all cases of suspected cerebellar tumor.

We wish to emphasize the ease and safety of the electrocoagulation procedure and the fact that it is apparently unnecessary to destroy the feeding vessels of the tumor. While a pink lesion remains at the original site in the present case, we believe that the retinal angioblastoma has been occluded, for there is no longer any retinal exudate (a tumor product) and the pink area is flat and nonstriated. Moreover, the vessels of the tumor have shrunk to almost normal size, with partial

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7 Davison, C., Brock, S., and Dyke, C. G. Retinal and Central Nervous Hemangioblastomatosis with Visceral Changes, *Bull. Neurol. Inst. New York* 5: 72-93 (Aug.) 1936.

8 Craig, W. M., Wagener, H. P., and Kernohan, J. M. Lindau-von Hippel Disease, *Arch. Neurol. & Psychiat.* 46: 36-54 (July) 1941.

9 MacDonald, A. E. Lindau's Disease. Report of Six Cases with Surgical Verification in Four Living Patients, *Arch. Ophth.* 23: 564-576 (March) 1940.

10 MacNab, G. H. Lindau's Disease. Case Report, *Proc. Roy. Soc. Med.* 34: 324-325 (April) 1941.

11 Cushing, H., and Bailey, P. Tumors Arising from the Blood Vessels of the Brain, Springfield, Ill., Charles C. Thomas, Publisher, 1928.

obliteration of the vein. Unfortunately, in spite of the roentgen therapy the involvement of the spinal cord is progressing inexorably. It is to be noted that radiation was given only to the lumbosacral area, while the neurologic signs point to invasion of the brain stem or upper cervical part of the cord by the neoplasm or by a concomitant syringomyelic cavity, as reported by König and Schoen<sup>12</sup>. Hirschfeld,<sup>13</sup> in 1944, achieved a favorable result in the roentgen treatment of a patient with Lindau's disease presumably involving the medulla. He observed that there were no reports in the literature of any attempt to treat spinal or medullary hemangioblastoma with roentgen radiation, an indication chiefly of the rarity of the lesion. It is planned to give our patient radiation to the upper cervical portion of the cord in the near future.

#### SUMMARY

A case of Lindau's disease with unusual manifestations is described. Compression of the cord was produced by a histologically verified sclerosing hemangioma arising from the cord, whereas a solitary coexisting retinal angioma was asymptomatic. The retinal tumor was attacked directly by electrocoagulation without any loss of vision, and the success attained by this means furnishes additional support for the view that puncture diathermy is the method of choice in the treatment of von Hippel's disease. The tumor of the cord had previously been treated with roentgen radiation, but one year later further involvement of the cord had occurred. It is suggested that fundoscopic examination with use of a mydriatic be made preoperatively in all cases of suspected tumor of the cord to detect isolated cases of Lindau's disease.

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12 König, E, and Schoen, H. Diffuse Angiomatosis of Medulla and Spinal Cord with Syringomyelia (Lindau Syndrome), *Beitr z klin Chir* **170** 239-265, 1939.

13 Hirschfeld, M H. Hemangioblastoma of Medulla. Lindau's Disease, Response to Radiation Therapy, *J Nerv & Ment Dis* **99** 656-659 (May) 1944.

# CORNEAL LIGHT REFLEX IN DIAGNOSIS OF RETINAL CORRESPONDENCE

EMANUEL KRIMSKY, M D  
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**E**YES normally work together in close harmony by virtue of an intimate understanding between the fovea or macula of one eye with that of the other. These retinal components are called corresponding retinal points, and when identical impulses strike both maculas they register a fusion response in the brain which is called binocular, or binocular, fixation (fig 1). It is quite possible that such identical impulses may strike these corresponding retinal points and not register

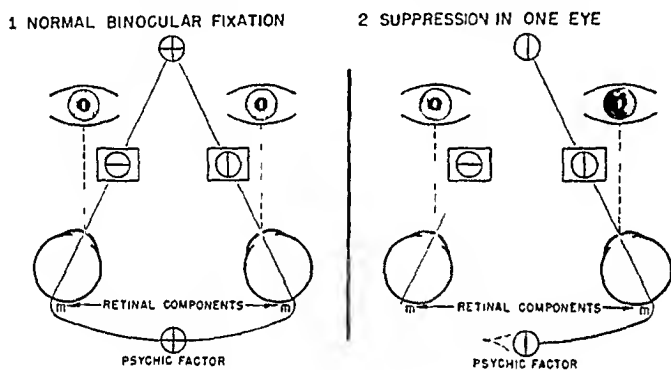


Fig 1—Corresponding retinal points

fusion because of a break in some part of the visual pathway behind either eye, so-called monocular suppression. Therefore, the psychic assimilation or fusion of impulses on corresponding retinal points determines whether or not the person has retinal correspondence.<sup>1</sup>

## RETINAL CORRESPONDENCE

Any form of retinal correspondence, whether it is normal or abnormal, is associated with some form of psychic interpretation, in contradistinction to so-called corresponding retinal points, which have a purely geometric conception. The term, therefore, is inadequate because

Read in part at a meeting of the New York Society of Clinical Ophthalmology, Oct 7, 1946

<sup>1</sup> Bielschowsky, A. Etiology of Strabismus, *Am J Ophth* **20** 478-489, 1937, *Physiology of Ocular Movements*, *ibid* **21** 843-854, 1938

it stresses the retinal element only. A more correct term would probably be psychoretinal correspondence. The terms retinal correspondence and retinal projection are used interchangeably, the former suggests a sensory component and the latter a motor component. Here, too, such refinements in terminology appear unnecessary, and it is the central, or psychic, factor which determines the ultimate response. The term retinal projection would seem to place the retina in the same category as automobile headlights or reflectors.

Normal retinal correspondence is a term employed to indicate registration of identical impulses on corresponding retinal points and assimilation in the brain of a fused image. The term itself does not necessarily indicate that the eyes are operating in normal fashion. It merely indicates that the brain can be made to fuse images that strike both maculas. In normal binocular fixation such correspondence is taken for granted. However, in a case of manifest squint it is conceiv-

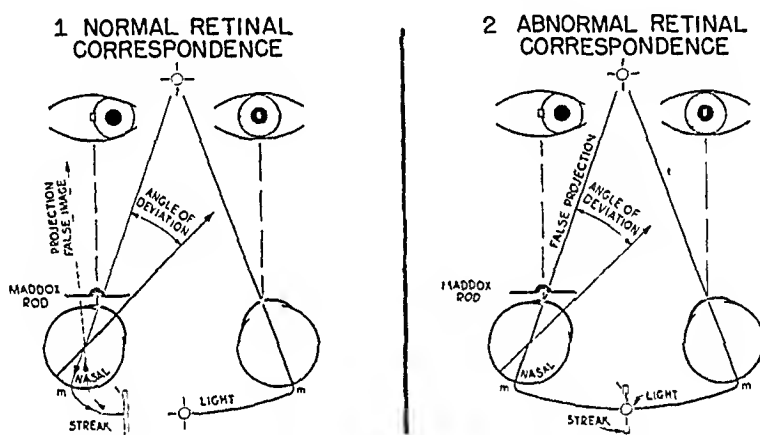


Fig 2—Retinal correspondence and false projection

able that a common light source will not reach both maculas directly, and, therefore, it is necessary through artificial means to shift or bend the light rays so that they will reach the two maculas simultaneously and thereby register fusion. Because normal retinal correspondence means binocular fusion, it is important to indicate whether it is part of normal binocular fixation or part of a manifest squint.

Abnormal retinal correspondence,<sup>2</sup> in contradistinction to normal retinal correspondence, is a macular-paramacular association because the deviating eye learns to accept a paramacular stimulus. As such, it is practically always associated with a manifest squint.

#### FALSE PROJECTION

False projection is a term often used to indicate the projection of a false image in case of binocular diplopia associated with paralytic

<sup>2</sup> Travers, T. a'B. Origin of Abnormal Retinal Correspondence, *Brit J Ophth* 24 58-64, 1940

squint (fig 2) It is also used loosely and synonymously with abnormal or anomalous or secondary correspondence or projection Binocular diplopia is neither normal nor abnormal retinal correspondence, for there is no psychic adjustment or correspondence It is in reality a disturbance in normal retinal correspondence in which normally corresponding retinal points have been thrown out of alinement

In abnormal retinal correspondence the deviating eye develops a new angle of projection which corresponds to or approximates the primary, or binocular, angle This angle is also called "false projection" While there is no uniform terminology, it is important to specify whether or not this false projection is part of a readjusted abnormal retinal correspondence or of a paralytic squint or of normal retinal correspondence

#### EVOLUTION OF ABNORMAL RETINAL CORRESPONDENCE

Any speculation on the origin of abnormal retinal correspondence is merely hypothetical because a manifest squint may show normal or abnormal retinal correspondence or a combination of the two However, some form of visual understanding might help one to explain the nature of fusion response associated with this condition One can conceive of a disturbing diplopia with paralytic squint becoming gradually less with time because of suppression of a false image Instead of binocular diplopia, one now has monocular vision with concomitant relative suppression in the nonfixing eye Spontaneous fusion is for all practical purposes absent because fixation is monocular It is, however, suppressed only as a result of such deviation, and artificial stimulation of both eyes can often be shown to awaken momentary or temporary return of the binocular diplopia corresponding to the amount of the deviation and the position of the displaced corneal light reflex This would indicate normal retinal correspondence

In another case of squint, however, with the same amount of deviation such artificial light stimulation of the eyes will produce a diplopia with the two images close together even though the position of the eye and the displacement of the corneal light reflex suggest much greater separation of false and true images This indicates abnormal retinal correspondence One cannot predict in which case normal and in which abnormal retinal correspondence will develop or be manifested

#### THE CORNEAL LIGHT REFLEX AS AN AID TO MEASUREMENT OF SQUINT

I mentioned that squint may show either normal or abnormal retinal correspondence The corneal light reflex is an infallible guide in measuring strabismus The mere displacement of a corneal light reflex

is only of qualitative value and is therefore unsatisfactory for purposes of measurement. My reasons for this assertion were explained in a previous article<sup>3</sup>

The accurate measurement of squint is a most important preliminary consideration in studies of fusion and retinal correspondence. It is axiomatic that a corneal light reflex is displaced in a squinting eye from its position of fixation. Any artificial means that could restore the position of the corneal light reflex to a central or fixational position also serves as a measure of the squint (fig 3). The prism reflex test which I described has proved a method *par excellence* and can be used by any practitioner with but little practice. The refined Brewster stereoscope, the angiometer and the synoptophore are additional aids in the controlled examination of squint and of retinal correspondence. Unless targets are translucent and brightly illuminated to register satisfactory corneal light

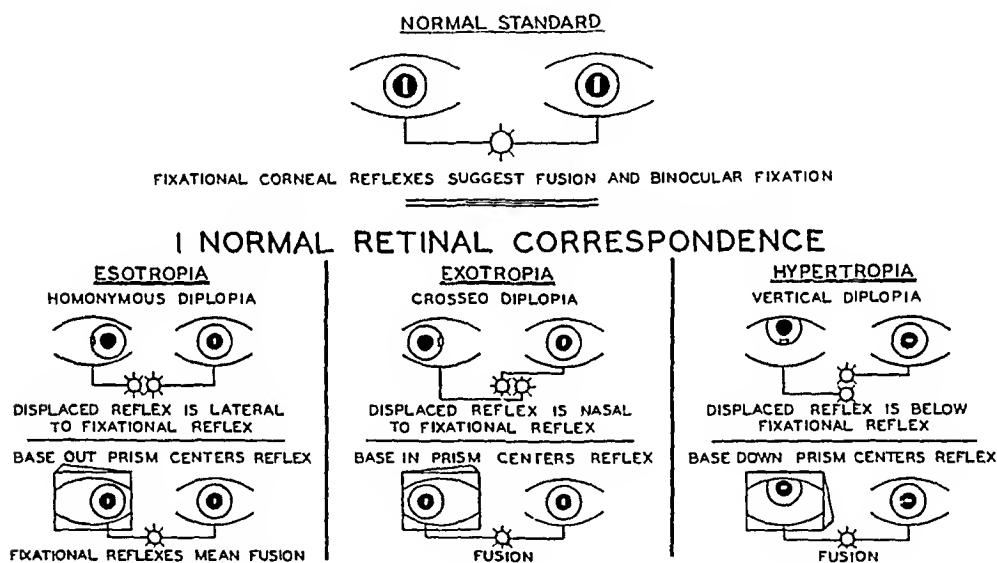


Fig 3—Binocular projection in relation to corneal light reflexes normal retinal correspondence

reflexes and, moreover, can be flexibly adjusted to correspond to the visual axes for the two eyes, no stereoscope is of value. The phorometric stereoscope provides a comprehensive method for studies not only at the equivalent range of infinity but at selected ranges of accommodation. Each of these three instruments employs the principle of independent light sources and an intervening septum or independent viewing arrangement. The angiometer, moreover, can be used without the septum in conjunction with the prism reflex test and the Maddox rod in selected cases.

3 Krinsky, E. The Fixational Corneal Light Reflexes as an Aid in Binocular Investigation, *Arch Ophth* 30 505-521 (Oct) 1943



# RETINAL CORRESPONDENCE IN RELATION TO CORNEAL LIGHT REFLEXES

The position of the corneal light reflex is a dependable means of interpreting the direction or projection of the false image both in cases of paralytic diplopia and through artificial stimulation in cases of normal retinal correspondence. In abnormal retinal correspondence, the position of the corneal light reflex does not correspond to the position or direction of the false image produced by adequate artificial stimulation. Thus, the position of the corneal light reflex as an objective sign is of decisive value in differential diagnosis when compared with image responses (fig 3). If one conceives of a central or a fixational position of the corneal light reflex as indicating projection forward, then any displacement of the corneal light reflex in relation to this fixational position should suggest false projection in a relative direction. When the

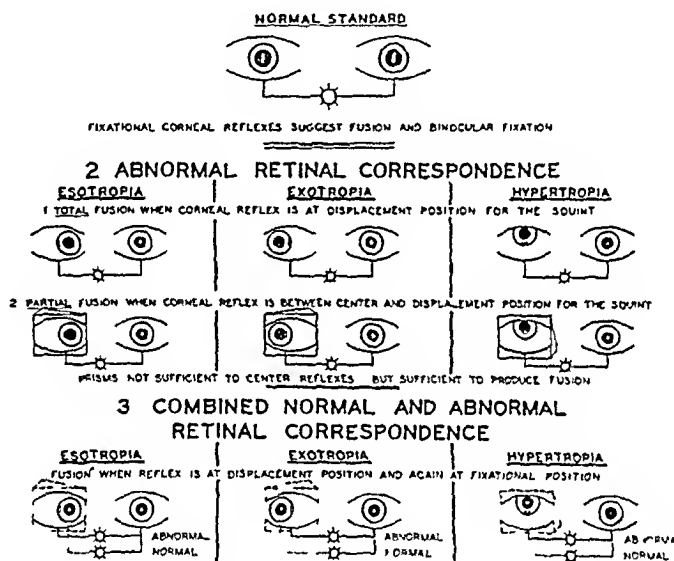


Fig 4—Binocular projection in relation to corneal light reflexes abnormal retinal correspondence

reflex is displaced upward in relation to the fixational position, the false image is likewise displaced upward. When the reflex is displaced outward, the false image is outward, or homonymous. The reflex can be displaced outward only when the eye is deviated inwardly. The amount of displacement of the light reflex from the fixational position suggests the magnitude of separation of the true and false images. In normal retinal correspondence the projection of the false suppressed image would conform to such displacement of the corneal reflex. In abnormal retinal correspondence, on the other hand, even though the light reflex is displaced there is a tendency for approximation or superposition of the false and the true images at or near the primary, or binocular, angle (fig 4).

## NATURE OF FUSION IN ABNORMAL RETINAL CORRESPONDENCE

I stated previously that in abnormal retinal correspondence both the squinting and the fixing eye attempt under artificial conditions to project images registered in the brain to or near a common point, even though the corneal light reflex is displaced in one eye. This can be attained only when a paramacular area of the retina in one eye coordinates latently with the macula of the fellow, or fixing, eye, in other words, when there is a macular-paramacular association. In convergent squint, the corneal light reflex is displaced temporally but the registration on the retina is nasal, and the retinal correspondence would be macular-nasomacular. In divergent squint, the corneal light reflex is displaced medially and the image on the retina is received temporally, and the retinal correspondence would be macular-temporomacular. This paramacular area is sometimes erroneously termed the "false macula" because the image strikes an area other than the true macula (fig 5)

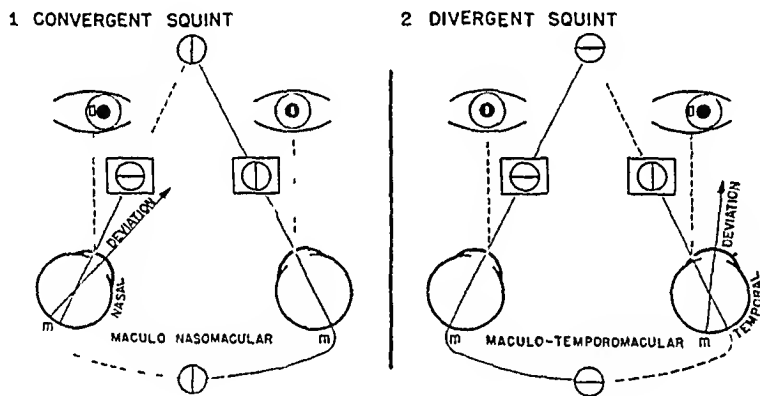


Fig 5—Association areas in squint with abnormal retinal correspondence

Just as a squint may be alternating, so may this macular-paramacular association be alternating or transferable when either eye assumes the role of fixation (fig 6)

In normal retinal correspondence, in contradistinction to abnormal retinal correspondence, the fusion obtained under artificial conditions is apt to be more critical because it is binocular. It is usually a latent macular-macular relationship, which can be manifested only by artificial means, such as prism, stereoscope or synoptophore. A prism that can "correct" a deviation will often awaken binocular registration, and even a latent fusion amplitude around this angle of deviation. With the stereoscope, too, such latent dynamic response can be induced when targets are brought into the range of the deviation. Such a dynamic response may confuse the examiner in establishing the angle of deviation, the von Graefe supplementary prism dissociation test prevents any possibility of fusion at the angle of the squint.

In abnormal retinal correspondence latent approximation or "fusion" of images is not binocular in correspondence. Hence, no fusion amplitude can be induced through artificial means.

A latent area of relative suppression is usually associated with both normal and abnormal retinal correspondence accompanying squint. This suppression serves to absorb the spontaneous false image. It is relative in the sense that it occurs only when fixation is assumed by the fellow (fixing) eye and is not necessarily related to loss in monocular visual acuity. The area and the severity of this suppression vary in different instances. This area can be mapped out with use of targets that subtend minimal retinal angles by various binocular methods which permit the nondeviating eye to assume the role of fixation. Travers employed a Bjerrum screen for the nonfixing eye and a mirror device for the fixing eye and aimed to plot the macular position of the suppressing eye by suitable adjustment of the fixing eye.<sup>4</sup>

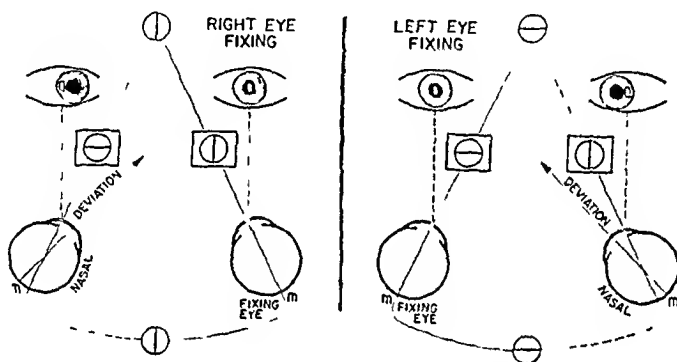


Fig 6—Abnormal retinal correspondence—an alternating phenomenon in a case of convergent squint

#### RELATIVE SUPPRESSION OF SQUINT (FIG 1)

A fused image of two separate targets as seen normally through a stereoscope has a more distinct component belonging to the dominant, or fixing, eye and a hazier one for the fellow, or so-called nonsighting, eye. The hazier component may prove blurred and indistinct in squint, owing to a larger zone of relative suppression, making it necessary to employ a larger target in order to register rudimentary fusion. When the zone of suppression is large and a smaller moving test object is brought gradually into the central binocular field, there will be sudden disappearance of image of this moving test object, only to have the image reappear as the target reaches the opposite side of the suppression area. This phenomenon is described as a "jump," or approximation, or crossing, of images without actual touching. The larger the target, the

<sup>4</sup> Travers, T. a'B. Suppression of Vision in Squint and Its Association with Retinal Correspondence and Amblyopia, *Brit J Ophth* 22: 577-604, 1938

less the chance of total fading. From the standpoint of the examiner, it is important to appreciate the physiologic basis of this phenomenon in evaluating painstaking measurements which sometimes seem to make no sense. It is also important to ascertain whether this relative suppression belongs to the macular or to the paramacular area. The relation of the zone of suppression to the position of the corneal light reflex seems to indicate whether it is part of normal or of abnormal retinal correspondence.

#### FALSE MACULA

False macula should be distinguished from so-called paramacula, which one usually associates with abnormal retinal correspondence. False macula is also termed eccentric fixation because the affected eye appears to be in a squinting position even though the other eye is covered (fig 7). It is not uncommon in cases of unilateral squint, and because



Fig 7—Photographs of false macula, or eccentric fixation, in one eye

the squinting eye suffers from disuse severe amblyopia is a common result. On alternate screening there appears to be no motion in either eye, such as one would expect in alternating squint. Vision is often reduced below 20/200, and when the affected eye is made to assume fixation by covering the good eye one often observes an unsteady nystagmoid movement, because monocular fixation is greatly impaired. Even in such cases of greatly reduced vision it is amazing to discover some form of suppressed or rudimentary correspondence of the two eyes.

Abnormal retinal correspondence, in contradistinction to so-called false macula or eccentric fixation, manifests good or passable vision in each eye, and monocular fixation is steady.

#### VARIATIONS IN ABNORMAL RETINAL CORRESPONDENCE

Abnormal retinal correspondence is not a clearcut entity so far as accuracy in measurement is concerned. It is clearcut only in the sense

that the "fusion" angle does not correspond to the angle of the deviation or to the fixational corneal light reflexes. Abnormal retinal correspondence may exist also in cases of vertical squint, in which artificially induced double images will appear on the same horizontal level even though the corneal light reflex and the eyeball are displaced vertically.

Abnormal retinal correspondence may, and often does, occur in association with normal retinal correspondence, and "fusion" or approximation of double images may be induced when the light stimulation corresponds to the displaced position of the corneal light reflex for the deviated eye and, again, when the light reflex is restored artificially (as by prism or stereoscope) to the central fixational positions for both eyes. The abnormal retinal component may be more prominent than the normal, and vice versa. As a rule, even when the abnormal element is intense, it is fairly easy also to awaken normal retinal correspondence by moving brightly illuminated stereoscopic targets in line with both visual axes or both fixational positions on the cornea. In thus awakening normal retinal correspondence, the abnormal component gradually becomes fainter, probably because the eyes prefer binocular correspondence if that were only possible. During this course of stimulation the patient may encounter triplopia or even quadrilopia, which, fortunately, is transient.

When the induced images suggest superposition at the primary, or binocular, angle but with the corneal light reflex corresponding to the actual ocular deviation, abnormal retinal correspondence is said to be total, or harmonious.<sup>5</sup> Often, however, the image angle corresponds to a corneal reflex position somewhere between the fixational position and the maximally displaced position for the deviation. In such case, the abnormal component is said to be partial, or subharmonious (fig. 4).

#### HOW TO ELICIT RETINAL CORRESPONDENCE

If by retinal correspondence one means a bivisual response or projection based on ample light stimulation, then the positions of the corneal light reflexes should tell one whether such correspondence is normal or abnormal.

Any method or apparatus which can produce clearcut corneal light reflexes that can be flexibly displaced through such artificial means should prove ample for one's requirements. Such methods include use of (a) the prism reflex test, (b) the phorometric stereoscope, (c) the anglo-meter, (d) the synoptophore and (e) the maddox rod.

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<sup>5</sup> Worth, C. Squint, edited by F. B. Chavasse, Philadelphia, P. Blakiston's Son & Co., 1939. Burri, C. The Concept of Abnormal Retinal Correspondence, Arch Ophth 19: 409-424 (March) 1938.

THE ROTARY PRISM IN THE ESTIMATION OF  
RETINAL CORRESPONDENCE

In a previous article, I reported the use of the rotary hand prism or the phorometer for restoring the light reflexes to a fixational position for the objective study of squint. The additional application of the prism reflex test in the diagnosis and measurement of retinal correspondence is, I believe, a newer departure in prism testing (fig 8)

The principle of this test is, first, artificial restoration of the corneal light reflex to a fixational position and, second, study of image responses after inducing diplopia with supplementary prism. Specifically, the test is carried out as follows

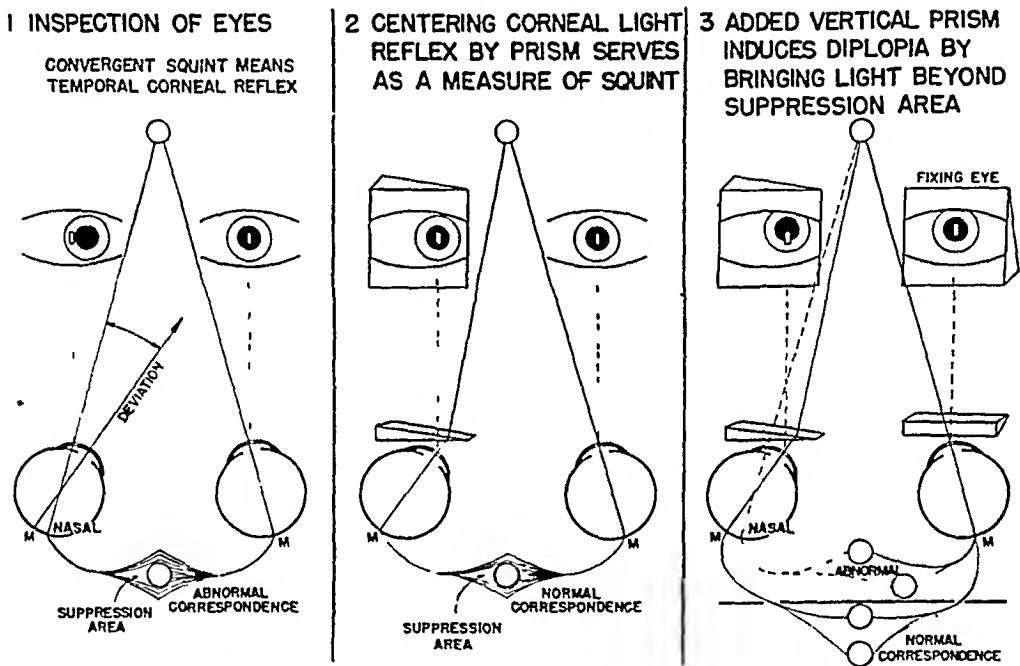


Fig 8—The phorometer in the study of retinal correspondence

1 Observations on the eyes and the positions of the corneal light reflexes. The fixational corneal reflex may be central or off-center. Instead of measuring the angle gamma position, the examiner merely makes a mental note of the position of the corneal light reflex, first monocularly and then binocularly. With a little practice, the examiner can learn to tell at a glance the fixational positions without having to involve himself in needless computations. As long as binocular fixation is maintained, say, with convergence of the eyes or in overcoming the effects of a prism, the corneal light reflexes will remain in their respective monocular positions. The examiner holds the light directly in front of the patient's eyes and at a distance of 13 inches (36 cm).

2 Measurement of the deviation by restoring fixational corneal light reflexes. The rotary hand prism is held before the deviating eye and

manipulated so as to produce movement of the corneal light reflex. If the corneal light reflex is temporal, as in convergent squint, a base-out prism before the deviating eye will restore the light reflex to a central, or fixational, position. If one thinks in terms of the apex of the prism and compares it to the point of an arrow it will be easy to figure out how to rotate the prism in order to centralize the corneal light reflex, because the point of the arrow will be in a direct line from the displaced position of the light reflex to the fixational position. If the examiner makes the mistake of rotating the prism in the wrong direction, the light reflex will move away, rather than toward, the center. The prism is kept free from dust, and the light reflex is observed through the prism. The amount of prism required to bring the light to the fixational position is the measure of the amount of squint. When the examiner believes that he has centered these light reflexes, he supplements with alternate screening to insure that motion has been stopped. If the rotary prism is placed before the fixing eye instead of the deviating eye, the light reflex will move in the direction of the apex of the prism. Such movement will also bring the deviating eye out, and here, too, the corneal light reflex will be gradually seen to become centered.

3 Image Response. Is there a latent tendency to normal or abnormal retinal correspondence? Usually the patient continues to see single as the corneal light reflex is gradually centered because of latent suppression in one eye. By inducing diplopia after reflexes are centered, one can determine whether retinal correspondence is normal or abnormal. In normal retinal correspondence images approach or cross at or near the binocular angle corresponding to the fixational corneal light reflexes. In cases of horizontal squint my associates and I induce vertical diplopia after the corneal light reflexes are restored to fixational positions by rotary prism. A supplementary prism of 10  $\Delta$  base down over the eye not covered by the rotary prism (fig. 9) will be sufficient to overcome suppression and induce diplopia. If necessary, a stronger prism may be required. The corneal light reflex will be in a central, or fixational, position in one eye and displaced vertically in the other eye. Such artificial vertical displacement of the corneal light reflex in one eye by prism likewise registers true vertical diplopia in normal retinal correspondence. In abnormal retinal correspondence double images appear oblique because association is macular-paramacular. In other words, the subjective angle does not correspond to the objective, or deviation, angle. By rotating prism to bring images into true vertical alignment, we now obtain a reading for the subjective angle, but such operation of the prism has now altered the position of the corneal light reflex away from the objective angle. An appreciable disparity in prism readings for subjective and objective angles points to abnormal retinal correspondence. Prism readings for the image, or subjective, angle (true vertical

diplopia) will always be found nearer the 0 position than the reading for the deviation, whether it be an esotropia or an exotropia

In vertical squint we study image responses by inducing diplopia with base-in or base-out prisms. When such induced double images are found to be horizontal in the presence of vertical deviation and vertical displacement of the corneal light reflex, the condition points to abnormal retinal correspondence. Furthermore, the eyes will be seen to move up and down to meet images that appear on the same level. In normal retinal correspondence such induced double images will be found on different levels, and "correction" of the vertical squint by vertical prism sufficient to bring the corneal light reflex to the fixational level will likewise level the images and overcome up and down movements of the eyes to meet the images.

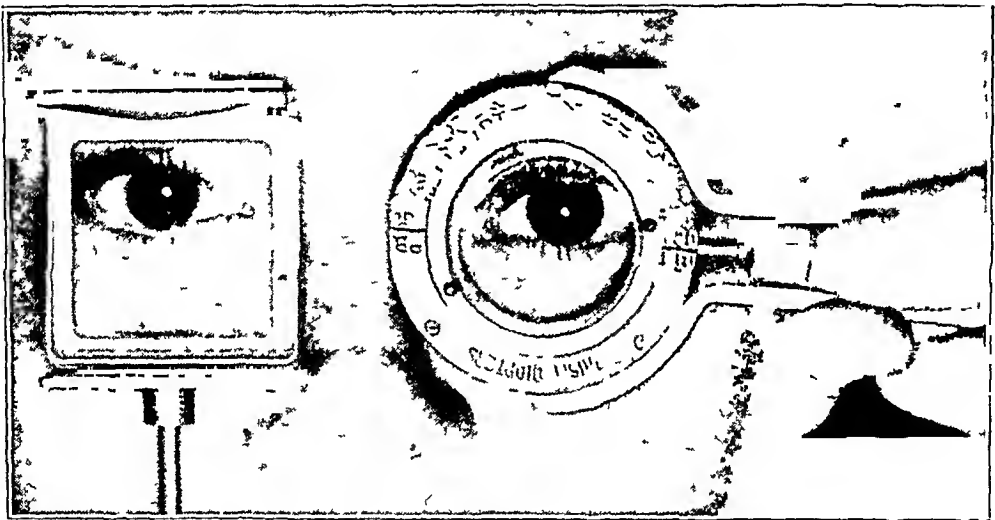


Fig 9—Krimsky prism holder and rotary prism

#### THE MADDOX ROD AND RETINAL CORRESPONDENCE

The Maddox rod may be used as a substitute for the von Graefe dissociation test. After the corneal light reflex is restored by prism to a fixational, or binocular, position in the deviating eye, the Maddox rod is then placed over either eye, in cases of horizontal squint the rod is placed horizontally to produce a vertical streak and in cases of vertical squint it is placed vertically to produce a horizontal streak (fig 10).

Normally, the image of the streak should meet the spot of light at the binocular angle when both corneal light reflexes have been made fixational. In orthophoria superposition is automatic. In heterophoria or in normal retinal correspondence such approximation can be obtained only when the corneal light reflex in the deviating eye is brought into a fixational position by means of rotating prism. Inspection of the



corneal light reflex behind the Maddox rod may not be possible. However, if the examiner instructs the patient to fix his attention on the streak rather than on the spot of light the eye behind the Maddox rod will be brought into a fixational position and displacement of the reflex in the uncovered, or nonfixing, eye can therefore be observed and studied. Instead of alternate screening to determine when motion of the eyes has finally stopped with sufficient prism, the examiner may simply ask the patient to fix alternately the streak and the spot of light and then note when motion has been arrested.

In normal retinal correspondence superposition of light and streak occurs when the corneal light reflexes have been brought to the fixational corneal positions and when alternate fixation produces no movement of the eyes. In abnormal retinal correspondence approximation of light and streak will occur in spite of displacement of the corneal light reflex.

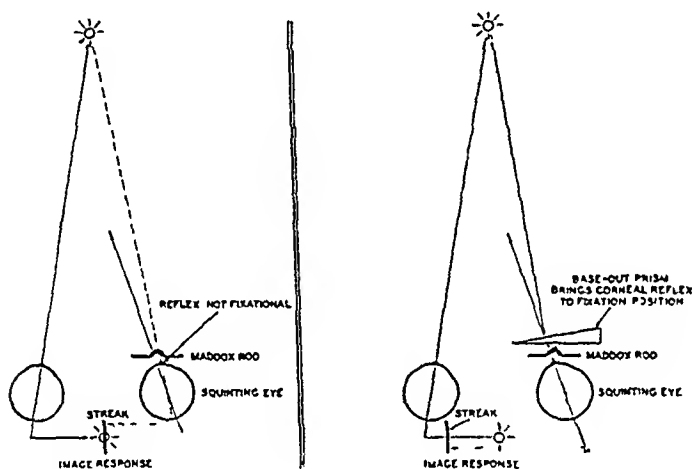


Fig 10—The Maddox rod in the study of retinal correspondence. The rod is held at a 13 inch distance.

in one eye, and alternate fixation of streak and light will still yield appreciable movement of the eyes in order that the patient may see images which appear very close together. In other words, the image angle does not correspond to the angle of deviation, or objective angle.

In cases of vertical squint, the Maddox rod is placed vertically before either eye to produce a horizontal image of the streak. With both eyes open, the streak will appear higher or lower than the spot of light in normal retinal correspondence, and when the vertical deviation, as well as the vertical displacement of the corneal light reflex, is "corrected" by vertical prism, both the spot of light and the streak will appear leveled and there will be no up and down movement of the eyes on alternate fixation of respective images. In cases of abnormal retinal correspondence, whether total or partial, when images are found or made level

by prism that does not fully correct, the corneal light reflex will still be vertically displaced and there will be appreciable up and down movement of eyes on alternate fixation of light and streak

Incidentally, I rely on the movements of the lids, as well as on movements of the eyes. When the eyes move exactly up and down, the lids will respond in the same way. The slightest oblique movements of the eyes will show themselves in analogous excursions of the lids

#### THE ANGLOMETER IN THE DIAGNOSIS OF RETINAL CORRESPONDENCE <sup>6</sup>

The angiometer is an arclike arrangement pivoted on the sides rather than in the center, as in the perimeter. The entire arc, therefore, can be made to move up and down to correspond to the upward and downward movements of the eyes. Its movable lighted targets are flexibly moved along the arc into any desired testing position to the right or the left for any selected level of gaze. Each target carrier,

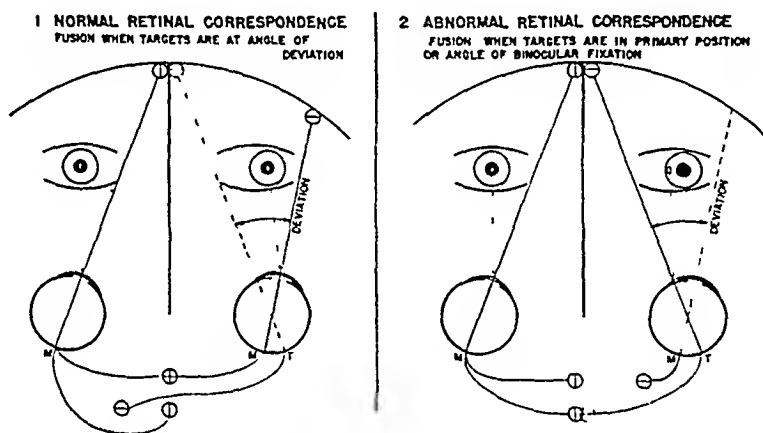


Fig 11—The angiometer in the measurement of divergent squint and retinal correspondence

moreover, permits independent raising or lowering of the test light to correspond to the vertical, as well as to the horizontal, deviation. Not only are such deviations noted readily in relation to a fixed position for either eye, but the examiner is also in a position to know exactly how many degrees upward or downward such measurements are made. Alinement of the targets to the deviation of one eye can be determined at a glance when the corneal light reflexes have been moved into their respective fixational positions and ocular movements have been arrested by alternate flashing or fixation. In normal retinal correspondence the image angle represented by fusion or approximation of images corresponds to the deviation reading, as determined in the preceding section. In abnormal retinal correspondence superposition or crossing

<sup>6</sup> Krinsky, E. The Cardinal Angiometer, *Arch Ophth* 26:670-674 (Oct.) 1941

of images will occur at a different setting, which will require further movement of targets in order to bring such images together. At this new, or subjective, angle the light reflex will no longer be in the fixational position on one eye, and the eyes will be seen to move appreciably from one image to the other, even though they appear to be touching or very close together. In such cases, the subjective (or image) angle and the objective angle do not correspond, and one notes the two different readings (fig 11)

In measuring deviation, the examiner instructs the subject to maintain fixation on one of the targets. He then disregards that eye as well as

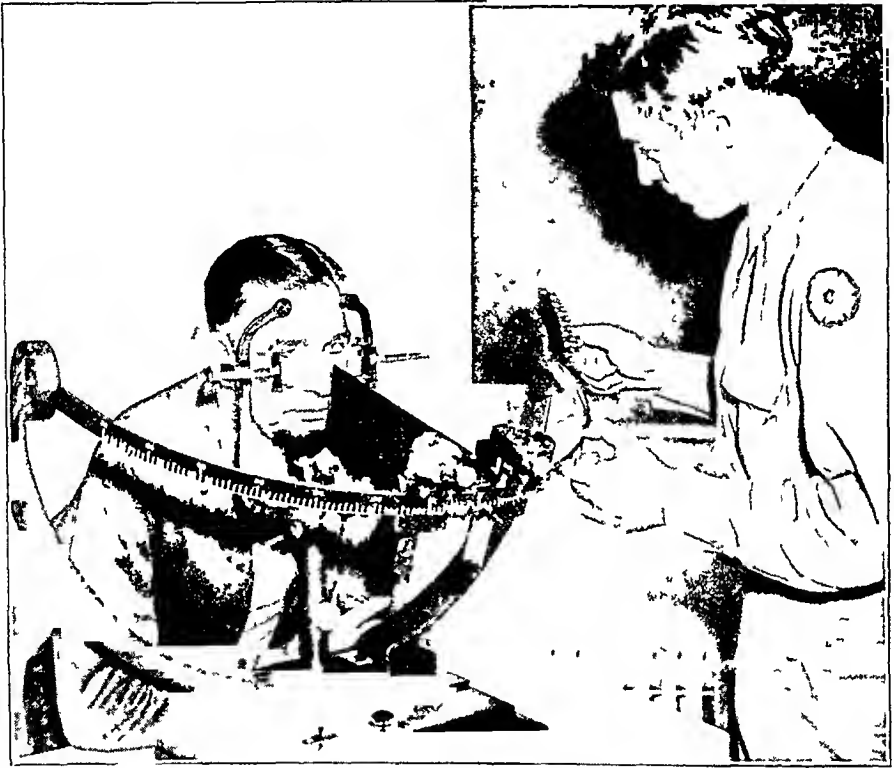


Fig 12 —The cardinal angiometer

that target and merely operates the target to the deviating eye so as to restore the light reflex to a fixational position. In moving such a target, he keeps his eye at all times behind the light, so as to obtain the true effect. He first corrects the horizontal component of the deviation by moving the target carrier along the arc. Often, with a little experience he will arrive at the correct reading and will note the angular deviation on this calibrated arc, which he will record in relation to the position of the fixing eye along the arc. There may be an additional vertical disparity, and the target holder enables the test light to be raised or lowered and vertical readings also to be noted in degrees. In addition

to restoration of fixational corneal light reflexes, he looks for cessation of ocular movement on alternate fixation or flashing. He also notes image responses. If the two lights appear fused or near together at this deviation reading, normal retinal correspondence is indicated. If another setting of targets is required to produce superposition of images, the examiner now notes the reading for the superposition or image angle, as well as the reading for deviation angle, in terms of abnormal retinal correspondence.

Examination with the angiometer is simple and direct and conforms to accepted principles of binocular study. Because there is no collimating lens, the findings conform more closely to what one would expect with the cover test. In other words, it aims to serve as a quantitative cover test for a fixed distance of 13 inches (33 cm), but with

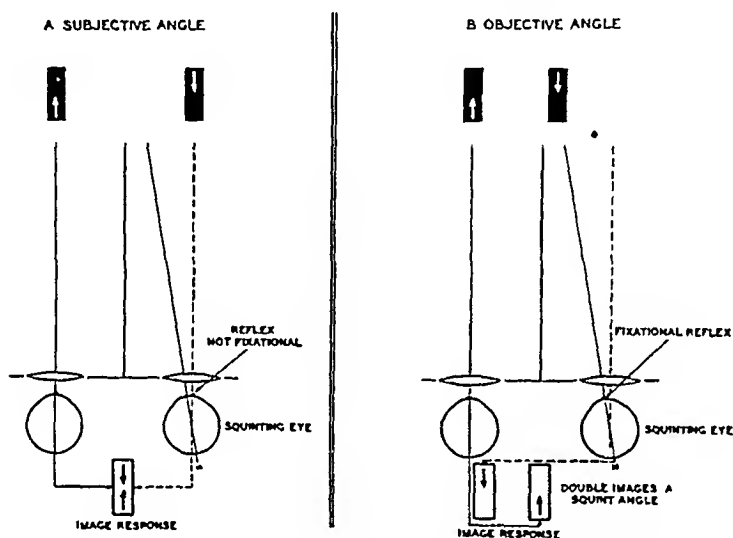


Fig 13—The stereoscope and use of displaced targets in the study of retinal correspondence

the added advantage that the examiner can readily test the eyes for any measured and selected position of gaze without worrying about instinctive movements of the head. Control of the fixational corneal light reflex is most satisfactory and is unhampered by prisms or lenses. Because study of cardinal or extraprimary positions is limited to a distance of about 13 inches, the test fulfills the requirements for investigation of the motor fields (fig 12). The angiometer, by virtue of its archlike arrangement, yields readings in arc degrees and can be adjusted readily to selected positions of the eyes in a measured direction of gaze and with fixed control of the head, the phorometer, or rotary prism, is essentially a phoria instrument which provides readings in prism diopters for the primary position of gaze and is limited to the lesser degrees of squint.<sup>6</sup>

## THE PHOROMETRIC STEREOSCOPE AND RETINAL CORRESPONDENCE

The Brewster type of stereoscope has carried with it an unfortunate prejudice, namely, that it is thought to be inadequate in the diagnosis of ocular deviation and retinal correspondence by those trained in the Wheatstone school. It is true that the Wheatstone type of stereoscope or synoptophore has been improved for such studies. However, the simpler type of Wheatstone instrument or Worth amblyoscope, without a calibrating system and effective illumination, is not much more satisfactory than the simpler type of Brewster stereoscope. A distinction is made between the major and the minor amblyoscope. The Brewster instrument is still excluded as a minor, even though it has been dressed up by commercial outfits with elaborate flashing units, modernistic designs and other features to detract one from the idea that it could still be a simple instrument bidding for popularity.

To transform a Brewster instrument into a clinical instrument, it was necessary to introduce the following changes: (1) brightly illuminated, transparent targets, which yield clear corneal light reflexes, (2) ease in inspection of corneal light reflexes through a reflecting mirror, (3) reduction in size of targets to permit greater range of amplitude, (4) calibrating arrangement, which automatically adjusts the targets to the primary positions for selective ranges of accommodation, (5) elimination of the antiquated caboose-like viewing head to permit increased flexibility in accommodation and to keep the eyes exposed, (6) provisions for supplementary square prisms, and (7) increase in the area of peripheral retinal stimulation and in the light intensity by merely bringing the targets closer to the eyes.

Through such improvements,<sup>7</sup> it has been possible to adapt this type of instrument to the large majority of patients with convergent squint up to at least 70  $\Delta$  both for the 0 and for the 3 D range of accommodation. For larger readings one must think surgically, and if exactness in measurements is desired an archlike apparatus appears more satisfactory.

In measuring deviation with the stereoscope, the patient maintains fixation of one eye on the corresponding target and the position of the corneal light reflex is observed in the nonfixing, or deviating, eye. The targets can be approximated ("converged") or separated ("diverged") mechanically, and corresponding displacement of the corneal light reflex is observed through the mirror. As soon as the reflexes appear in the fixational positions, alternate flashing or fixation of targets is done to observe whether movement of the eyes has been arrested. Image response is also studied, that is, it is noted whether the two images meet closely at this angle of deviation or appear widely separated. Super-

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7 Krinsky, E. Modification of the Brewster Stereoscope for Clinical Requirements, *Arch Ophth* 26 808-815 (Nov) 1941

position or approximation of images at this objective angle speaks for normal retinal correspondence. Wide separation of images requiring further displacement of targets to produce such superposition brings them out of alinement with the angle of deviation and hence speaks for abnormal retinal correspondence.

#### CONCLUSIONS

1 Abnormal retinal correspondence is a compensatory rudimentary macular-paramacular association between a fixing and a squinting eye.

2 Only under artificial conditions can such a latent partnership be demonstrated, because a relative suppression exists in the nonfixing eye.

3 Retinal correspondence, whether normal or abnormal, must have a psychic association, otherwise there can be no functional retinal correspondence.

4 Normal retinal correspondence is not necessarily, as its name implies, a normal condition. It merely indicates fusion or approximation of images which strike corresponding macular areas of the retina. Such correspondence occurs normally and spontaneously in normal binocular fixation and artificially in cases of squint.

5 An accurate measurement of ocular deviation is a necessary preliminary to the study of retinal correspondence. Artificial restoration of the corneal light reflex to a central, or fixational, position is, in my opinion, the most reliable method of measuring accurately ocular deviation.

6 The displaced corneal light reflex is dependable only so far as one can judge whether deviation is present. Estimation of deviation based on mere inspection of the position of the displaced reflex appears crude and inaccurate.

7 The prism reflex test is a gratifying method for centralizing the corneal light reflex. The amount of prism required to center the light reflex is, likewise, a measure of the amount of squint. When combined with the screen or cover test, it is confirmatory.

8 To interpret squint solely on the basis of deviation implies disregard of functional and psychologic responses. Every patient who has squint with vision in each eye has some form of retinal correspondence.

9 The position of the displaced corneal light reflex in relation to the position of the fixational reflex tells one at a glance the projection of the false image in paralytic squint and in normal retinal correspondence.

10 One cannot tell from the mere appearance of a squint whether there is normal or abnormal retinal correspondence or both. Some form

of retinal correspondence or rudimentary fusion exists in practically every case of squint without a pathologic condition

11 One should think of fusion response in terms of gradation, much as one thinks of visual acuity

12 The fusion which occurs in normal binocular fixation is sufficiently secure to enable amplitude or flexibility in both the convergence and the divergence range Fusion in manifest squint is suppressed but can usually be awakened in some degree by adequate artificial stimulation

13 In normal retinal correspondence there is often produced a fusion amplitude in the region of the deviation, in abnormal retinal correspondence there can be no fusion amplitude because correspondence is not binocular

14 The "fusion" that can be awakened in squint by brief artificial stimulation or "exercise" reverts to its status of inertness or relative suppression unless the position of the eyes can also be rectified

15 Abnormal retinal correspondence is subject to variations It may be total or partial, vertical or horizontal, or it may be combined with normal retinal correspondence Furthermore, responses vary with different tests

16 The diagnosis of abnormal retinal correspondence does not belong to the province of orthoptics It is as intimately associated with clinical ophthalmology as is refraction or perimetry, and its interpretation is part of medical and surgical judgment The diagnosis of retinal correspondence is more important than its actual measurement Exactness in measurement is desirable, but flexibility in judgment is even more important

17 The subject of normal and abnormal retinal correspondence offers a field for intriguing clinical research Measurement of deviation alone is merely an introduction to the study of squint and therefore tells but half the story

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# TRANSPLANTATION OF THE VITREOUS

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THIS experimental study was embarked on to determine the feasibility and limitations of transplanting the vitreous. The vitreous has proved to be one of the most difficult parts of the eye to deal with, and has been approached by a small number of workers in different ways, with scant success. The experimental studies on this structure have been remarkably few considering its importance and volume, probably because most ophthalmologists have a great fear of the vitreous and want to stay away from it. It does not take an ophthalmic surgeon long to learn that it is desirable never to see the vitreous, as its loss, injury or infection is poorly tolerated. The diseases of and degenerative changes in the vitreous are subtle and are not well understood, worst of all, they do not respond to the treatment heretofore available.

Withdrawal of the vitreous as a therapeutic measure was performed by Ford<sup>1</sup> and zur Nedden<sup>2</sup>. The latter found that he could remove up to 0.6 cc without apparent damage, and even with benefit in some cases. Deutschmann<sup>3</sup> performed the first recorded transplantation of vitreous from calf and rabbit eyes into the human eye. Komoto,<sup>4</sup> Lowenstein and Samuels<sup>5</sup> and Elschmig<sup>6</sup> removed vitreous and replaced it with saline solution. A number of men, among them Elschmig, have

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The work was done under a grant from the William L. Hernstadt Fund in the Ophthalmic Service at Montefiore Hospital for Chronic Diseases.

1 Ford, V. Proposed Surgical Treatment of the Opaque Vitreous, *Lancet* 1. 462, 1890.

2 zur Nedden, M. Ueber den Heilwert der Punktion des Glaskorpers, *Arch f Ophth* 101 145, 1919-1920, Das Instrumentarium zur Glaskorperabsaugung, *Klin Monatsbl f Augenh* 66 474, 1921, Ueber Glaskorperabsaugungen, *ibid* 67 305, 1921, Lanzenkanulen zur Glaskorperabsaugung, *ibid* 69 514, 1922.

3 Deutschmann, R. Zur operativen Behandlung der Netzhautablosung, *Klin Monatsbl f Augenh* 4. 364, 1906.

4 Komoto. Ueber Glaskorperwaschung bei unheilbarer Glaskorperblutung, abstracted, *Klin Monatsbl f Augenh* 50 265, 1912.

5 Lowenstein, A., and Samuels, B. Ueber Glaskorperersatz, *Arch f Ophth* 80 500, 1911.

6 Elschmig, A. Ueber Glaskorperersatz, *Arch f Ophth* 80 514 1911.



injected air into the vitreous. Cutler<sup>7</sup> recently reported the transplantation of human vitreous from one patient to another in 3 cases, with a good visual result in 2 cases, though all the patients appeared blind before operation as a result of hemorrhage or infection of the vitreous. We were not aware of Cutler's work until the present study was almost ready for publication, and were extremely interested in his report.

#### PRESENT INVESTIGATION

Our studies were performed on the eyes of young albino rabbits. A number of difficulties were encountered and a number of eyes lost by following techniques described by previous workers. Intraocular hemorrhage at the time of operation occurred in almost every case. A few days after the operation opacities of the vitreous and lens were seen in many of the eyes.

The rabbit eye proved more difficult to manipulate than the human eye, owing to the large lens in the small eye with a small vitreous space. The anteroposterior diameter of the young rabbit eye is 14.5 mm, as compared with 25 mm for the human eye. In the rabbit eye there is only 3.5 mm of vitreous space between the posterior surface of the lens and the retina, as compared with 16 to 17 mm in the human eye. There is little leeway, therefore, in entering the vitreous space in the rabbit eye, and great care must be exercised to avoid damage to the lens and the retina.

We thought that we should eliminate the danger of retinal detachment by sealing the retinal holes with diathermy, so preliminary surface diathermy was applied. However, we soon found that we could dispense with this procedure, since holes can be found in the rabbit's retina without a detachment developing. In 36 rabbits, on some of which we made repeated punctures, a permanent retinal detachment developed in only one eye. However, we should not dare to puncture a human retina without using diathermy to seal the holes, as experience with perforation of foreign bodies has demonstrated a greater tendency to detachment.

In all these procedures surgical asepsis must be maintained. Local and general anesthesia were used, but we soon found general anesthesia induced with pentobarbital sodium most convenient to employ.

As stated previously, simple withdrawal of vitreous had been done before, but we thought it of interest to repeat this in the rabbit. If no more than 0.3 cc of vitreous was withdrawn, there was only a transient conjunctival flush, and the globe was not altered in size or shape. Hypotony followed the withdrawal of vitreous but was of only

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<sup>7</sup> Cutler, N. L. Transplantation of Human Vitreous, *Arch Ophth* **35** 615 (June) 1946.

short duration The media stayed clear, and no retinal damage was noted

After the withdrawal of 0.4 cc or more of vitreous, the signs of disturbance became progressively severer, and the final results were disastrous Hemorrhages appeared on the iris and retina and occasionally in the vitreous Withdrawal of 0.9 cc of vitreous caused the eye to collapse like an empty tobacco pouch, so that the needle point almost invariably damaged the retina, and often the lens The conjunctiva became engorged and the vessels of the iris prominent, and blood appeared in the anterior chamber The eyeball gradually regained its shape, but the eye did poorly and usually degenerated

Histologic examination of eyes from which 0.9 cc of vitreous was withdrawn and the eye immediately enucleated disclosed the extensive damage that occurs on withdrawal of the vitreous in this manner The intraocular vessels were extremely dilated, and there were extensive hemorrhages in the anterior chamber, and into the iris, the ciliary body and the vitreous The choroid was detached as a result of hemorrhage and an accumulation of serous fluid, the retina was detached owing to hemorrhage

This histologic study revealed the reasons for some of the difficulties encountered in transplantation of vitreous The sudden withdrawal of a large amount of vitreous causes collapse of the globe and a sharp drop in intraocular tension, with loss of support for the blood vessels This produces a high degree of hyperemia and hemorrhages, with resulting rapid and profound damage to the eye Of course, the hemorrhages can be absorbed, but our experience with the eyes which were permitted to recover was not encouraging

The next studies consisted in removing vitreous in varying amounts and then replacing it with vitreous from the other eye, using a technic of withdrawal and subsequent injection similar to that described by Elschnig and others and recently by Cutler However, we found this method rather unsatisfactory The damage immediately following withdrawal of large amounts of vitreous, causing the globe to collapse, was so great that replacement of the vitreous, even within a minute, was not enough to correct it Large hemorrhages in the iris, retina and vitreous followed, so that most of the eyes were lost However, there was enough evidence to encourage us in the belief that the transplantation of vitreous was feasible

It became clear that it was important to avoid the collapse of the globe and the high degree of hypotony that followed withdrawal of large amounts of vitreous A double needle and syringe was devised to permit simultaneous injection and withdrawal of vitreous The mechanism consists of two needles soldered together, with their openings facing in opposite directions, and an arrest to stop the penetration

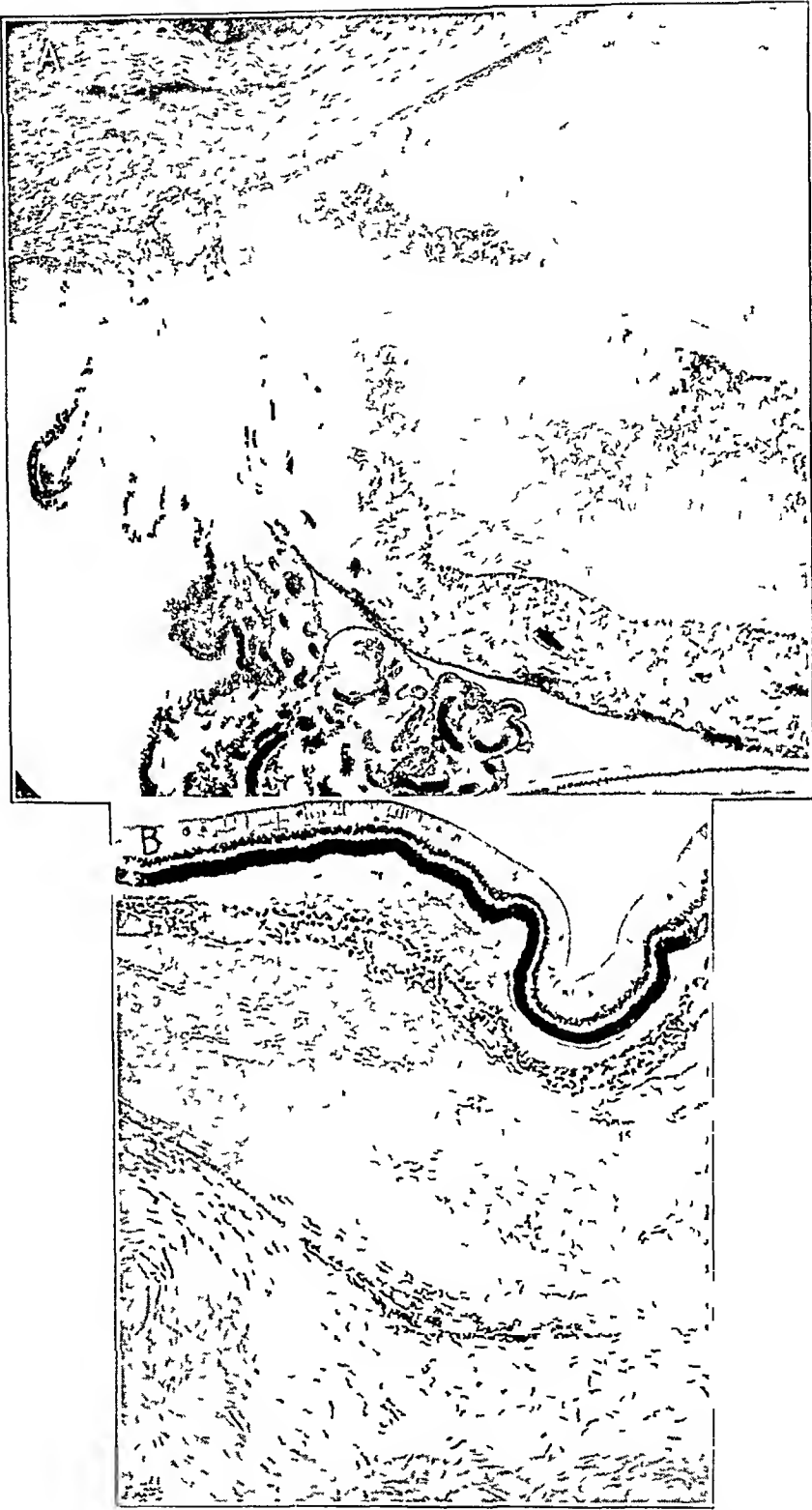


Fig 1—Rabbit eye from which 0.9 cc of vitreous was withdrawn (A) the anterior chamber contains a large hemorrhage, and the iris and ciliary processes are extremely hyperemic (magnification, 30), (B) subretinal and subchoroidal hemorrhages have detached the retina and choroid (magnification, 50)

of the needle at the level desired. One syringe is filled with vitreous to be injected, the other is empty. The double needle is inserted through the sclera up to the arrest and one operator injects vitreous, while the other withdraws vitreous from the eye.

The vitreous is a colloidal gel, which liquefies only too readily. The larger the bore of the needle through which it passes, the less it is injured. However, the larger the needle, the more damage is done to the eye. After considerable experimentation, it was found that use of the 18 gage needle was the best compromise for the rabbit eye.

With this method of simultaneous withdrawal and injection, we immediately noted a dramatic improvement in our results and found that transplantation of vitreous in the rabbit eye was easy and well tolerated, without untoward developments, in almost every case. There was no longer seen the hyperemia and hemorrhage in the iris, or even much conjunctival reaction. An occasional small hemorrhage was noted in the retina or vitreous, as well as occasional opacities in the vitreous, in only 1 eye was there retinal detachment, and in that eye scleral

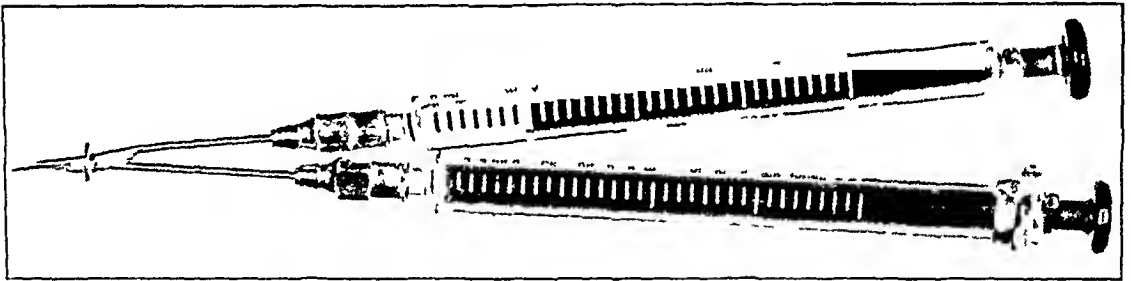


Fig. 2—Double needle for transplantation of the vitreous to permit simultaneous injection and withdrawal of vitreous.

diathermy had not been used. The intraocular tension was maintained fairly well throughout the procedure, a factor which is important in maintaining the form and function of the eye.

In some eyes saline solution was substituted for vitreous, but these eyes did well only if a small amount was used. With the substitution of larger amounts of saline solution, for vitreous, the eye did poorly. The best substitute for vitreous was found to be vitreous from another eye, and amounts up to 1 cc were successfully transplanted.

It made no appreciable difference whether we transplanted vitreous from the other eye of the same animal or from the eye of another rabbit. In 3 cases we transplanted vitreous from a recently enucleated human eye to the rabbit eye with complete success. The vitreous of a kitten's eye was transplanted to the rabbit eye without any disturbing reaction. The tolerance to transplantation of vitreous from other species was greater than was expected.

Histologic studies of a number of eyes were made at varying intervals after transplantation of vitreous. The puncture wounds of the sclera healed well. The edges of the retina curled up and the retinal hole remained, but there was no tendency to detachment. No significant damage was observed in the rest of the eye. The absence of degenerative changes after the extensive replacement of vitreous seemed significant and indicated the tolerance of the rabbit eye to the procedure.

Blood was injected into the vitreous and withdrawn at various intervals. The blood-vitreous mixture was withdrawn readily in a vitreous transplantation four hours after injection. When the blood stayed in the vitreous for several days, it coagulated in firm masses,

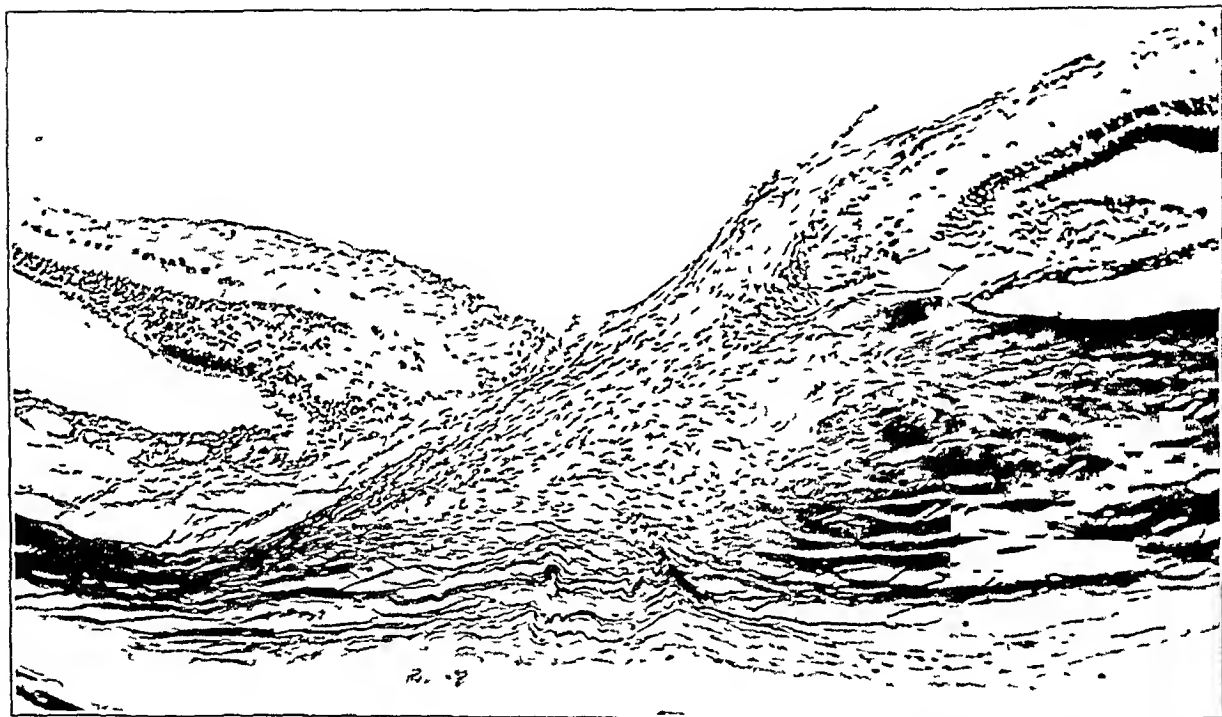


Fig 3—Eye of an albino rabbit which had been punctured with the double needle for transplantation of the vitreous, showing the retinal and choroidal hole and the healing of the scleral wound with connective tissue (magnification, 80)

which could not be withdrawn. In such eyes connective tissue bands formed in the vitreous, and later complicated cataracts developed. Apparently, blood must be withdrawn from the vitreous while still fluid. In the rabbit, a heavy coagulum forms rapidly and makes withdrawal difficult. Our impression is that in the human eye this coagulum does not develop so readily and may make transplantation of vitreous following hemorrhage more successful, as indicated by Cutler's<sup>7</sup> work.

With careful asepsis, we were able to perform a large series of transplantations of vitreous, with infection in only a few cases. The

vitreous is intolerant to infection, so unusual care is necessary to avoid contamination. Preservatives, such as penicillin and chlorobutanol, were tried, but they were not found to be superior to observance of a careful technic. The addition of chemical substances also raised concern over a possible alteration of the vitreous.

The vitreous was preserved by refrigeration at 0 C for varying periods up to one week. During that period it lost some of its clarity and became clouded, though it was found that it could be injected without apparent harm after such preservation.

There are many uses to which transplantation of the vitreous may be put, the following are noted only as suggestions, and further study will be required before they are applied to the human eye: (1) to replace bloody vitreous, (2) to replace degenerated vitreous, as in cases of high myopia or in any case with opacities of the vitreous which obscure vision, (3) to restore vitreous lost in operation or through injury, (4) to restore the volume of the eye and its normal tension after operations for retinal detachment, (5) to relieve hypotony from any cause, and (6) to replace infected vitreous, possibly with the addition of antiseptics and antibiotics.

#### SUMMARY

Transplantation of vitreous has been successfully performed in rabbit eyes. Vitreous from the other eye of the same rabbit or from the eyes of other rabbits was used, as well as vitreous from the human eye and from the kitten eye.

A method of simultaneous injection and withdrawal of vitreous with a specially devised double syringe and needle arrangement was the only method found to give regularly successful results.

Further studies are needed before the method is applicable to the therapeutic uses suggested in the human eye.

Miss Hilda Bergen assisted in these studies and made the microscopic sections.  
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## USE OF THE TELESCOPIC AMBLYSCOPE IN VISUAL TRAINING FOR DEFECTIVE VISION

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THIS paper is a preliminary report on the prognosis and treatment of a number of patients with ametropia, with vision ranging from 20/40 to 20/70 (amblyopic types) and higher refractive errors. All these patients had no definite pathologic condition of the eyes to account for the low vision, nor could the visual defect be corrected with glasses.

With the routine treatment as practiced in the clinic, if the patient was a young child, the mother was advised either to use atropine or to keep a continuous patch on the good eye, depending on the degree of amblyopia. The purpose of this measure was to encourage the eye with the poorer vision to function properly. If with this treatment several months elapsed with no visual improvement, the case was placed in the category of congenital amblyopia, with its accompanying poor prognosis.

Occasionally the patient was unaware of his poor vision because there were no subjective symptoms. Some persons knew they had a visual defect but neglected the condition. With other patients the ophthalmologist may have felt that since the visual acuity could not be improved the patient had better not become acquainted with his shortcoming lest he become apprehensive of some further ocular disaster. Since the situation could not be improved, the physician might reason that "what the patient doesn't know, won't hurt him" and that matters had best be left alone.

Many patients became truly aware of the condition only after a thorough physical examination in a military, health or life insurance survey, which included a thorough examination of the eyes.

In this investigation it was determined that the first series of patients for study and treatment should consist of a sufficient number of adults and children to permit determination of the possible merit of treatment with the telescopic amblyoscope. The series included a few patients with amblyopia previously treated unsuccessfully by atropinizing and patching the good eye. Some were amblyopic patients referred by other

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From the Departments of Ophthalmology of the Hospital of the Protestant Episcopal Church and St. Christopher's Hospital for Children.

ophthalmologists. The remainder were new patients whose vision could not be brought up to normal in spite of prolonged treatment with patching or atropinization of the normal eye, as well as reading exercises.

#### PRELIMINARY EXAMINATION

Vision of each of the first 19 patients to be examined was taken with three types of visual acuity charts. These patients, in addition, had their visual fields taken on the perimeter and the tangent screen. Each patient under 40 years of age had an ophthalmoscopic and a retinoscopic examination with use of a mydriatic. With patients over 40 the mydriatic was not used. Each patient was given the best possible correction. The glasses were worn for several months before visual training was suggested. Any muscle imbalance present was noted and treatment instituted. Other instruments available in the orthoptic clinic were made use of in the study and treatment of the patient if such a procedure was thought beneficial.

Of the 38 fields mapped for the first 19 patients examined, 8 presented mild contraction on the perimeter, and none showed any disturbance of the Mariotte blindspot. A few showed suppression scotomas.

By and large, the perimetric and tangent screen tests were not found to be of particular value, whether in diagnosis, prognosis or treatment. This was in accordance with findings in a previous study<sup>1</sup>. These tests were, therefore, omitted in the study of the succeeding cases. Central scotoma, if present, could usually be recognized by the eccentric fixation without perimetric studies as pointed out by Eggers<sup>2</sup>.

After the preliminary study only 10 of these 19 patients began the treatment schedule, they are included in the series of 47 patients reported here.

#### SUPPRESSION AS RELATED TO AMBLYOPIA

Suppression is a common obstacle in both good and poor vision. It is particularly frequent with squint but may also be present in persons without refractive error or squint. A review of the records of 39 patients treated at the squint clinic in the recent past showed that all had suppression. The suppressing eye had the higher error of refraction. To get an idea of how often persons without squint have suppression, 50 consecutive nonsquinting patients of various ages were examined. They had no particular ocular symptoms except those of eyestrain, or they came for an ophthalmic examination only because it was their habit to have their eyes examined every two years to make sure that their vision was normal. All those who were ametropic had their vision corrected to 20/20 with glasses before any tests for suppression were made. Some of the patients did not require glasses. In checking on the frequency of suppression in this group it was found that only 19 patients (38 per cent) had no suppression whatever. The other 62 per cent had suppression of various types. Fifteen patients (30 per cent) of the

1 Feldman, J. B., and Taylor, A. F. Obstacle to Squint Training—Amblyopia, *Arch. Ophth.* **27** 851 (May) 1942.

2 Eggers, H. Estimation of Uncorrected Visual Acuity in Malingerers, *Arch. Ophth.* **33** 23 (Jan) 1945.



total series had alternating suppression of varying degrees, from occasional to mild to moderately strong or severe, even though the original refractive error was in some cases equal to that of the patients in the same group who did not suppress. Ten patients (20 per cent) also had suppression of varying intensity of the right eye only, while 6 patients (12 per cent) had suppression of the left eye of varying degree. When there was absolute suppression of an eye, that eye had the higher refractive error. Even at that, vision in all eyes, whether suppressing or not, was corrected to 20/20. On examination a few patients were found to have suppression but did not require glasses.<sup>2</sup>

Even from this small series it must be quite evident that suppression is a condition common to human beings regardless of their visual acuity and does not play an important role in the causation of amblyopia. It was mentioned previously<sup>1</sup> that Vogt and Grandt asserted that ametropia is not the absolute forerunner of amblyopia, as was previously assumed.

Even after the study of this small group, one is inclined to feel that suppression, like ametropia, plays a small part in either the cause or the effect of amblyopia. However, when suppression is severe, a particular effort should be made to overcome it lest improvement of the amblyopia be delayed. Prognosis in a case of amblyopia with severe or absolute suppression should not be given until the suppression is somewhat overcome.

#### INSTRUMENT USED FOR TRAINING VISUAL ACUITY

The device can be easily and cheaply constructed. It is built like a telescope, with an eyepiece and an objective, and is unioocular. It is more accurate than the Wollensak Allscope,<sup>1</sup> since it is calibrated. It can be more easily handled by the technician. It can be used like the Wollensak Allscope as an aid in prognosis and, furthermore, can be used in treatment. The entire apparatus consists of an obelisk-shaped wooden box 1 meter in length, at the narrow end of which a viewing tube is placed. In this tubelike opening the eyepiece (*A*) has a —11.00 D sphere permanently inserted. In front of this is a lens holder (*B*), movable from side to side, in which is firmly set (*1*) a —2.00 D sphere, used for viewing targets during the lesson period at a distance of 1 meter, (*2*) a —6.00 D sphere, used in viewing the test chart at 20 feet (6 meters), and (*3*) a blank space for insertion of a lens of any other power for investigative purposes.

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3 Mrs. S. B., aged 47, the wife of a physician, had complete suppression of the left eye and yet had normal vision with a +1.25 D sphere for each eye. Mrs. L. W., aged 27, had alternating suppression and yet had normal vision with a —1.25 D sphere for the right eye and a —2.00 D sphere for the left eye. Still another patient, Mrs. R. R., aged 35, had unilateral suppression of the right eye with normal vision with a correction of +3.50 D sph +2.25 D cyl, axis 105, yet the left eye, with vision of 6/12 + with a correction of +3.00 D sph +2.25 D cyl, axis 80, had no suppression. It is of interest to note that in case 19 (table 2) of the present series vision was 20/20 in the right eye and 20/300 in the left eye and yet there was no suppression in either eye. (These 4 patients were not included with the 50 patients discussed in the body of the paper.)

In the body of the eyepiece is a  $+6.00$  D spherical lens (*C*), which can be moved  $\frac{1}{2}$  to 3 inches (1.25 to 7.5 cm) from the fixed  $-11.00$  D spherical lens *A*. A scale (*a*) on the eyepiece is marked off in  $\frac{1}{2}$  inch (1.25 cm) intervals, beginning at the fixed lens in the eyepiece. This scale gives the range of distance at which good focusing is obtained. A push button arrangement (*D*) on the holder of the lens (*C*) in the eyepiece housing moves the lens up and down. This stimulates the eye to overcome any existing suppression during the lesson.

At about the center of the device is the objective (*E*). Here is placed a  $+3.00$  D sphere actuated by a handle (*F*), effecting a movement from 6 to 14 inches (15 to 35 cm), which represents the distance from the eyepiece to the objective.

At the extreme end of the device is a lamp-housing device (*G*), in which are placed two 8 watt, fluorescent bulbs of daylight quality. In the lamp housing also are four 25 watt lamps, two in red and two in green, with separate switches for each colored lamp. The colored lights can be used with the colored targets of contrasting colors for the attainment of fusion of color when this is desirable. When a target is not inserted at the back of the lamp housing, a view of distance (infinity) is obtained. This is how vision is taken through the apparatus at 20 feet with a Snellen card as a target. A trapdoor (*H*) at the side can be used to insert an indicator to point out to the patient which part of the target is under discussion. Without the target the subject looks out into space, and therefore the apparatus has telescopic qualifications. For this reason, and for want of a better name, the device is called a telescopic amblyoscope.

#### TARGETS

The targets are improvised by taking heavy cardboard ( $6\frac{1}{4}$  by  $6\frac{3}{4}$  inches [15.8 to 17 cm]) and pasting thereon pictures showing detail, which the subject is required to describe carefully. Other interesting charts are news clippings from microfilm size newspapers. Targets are also made which utilize the smallest (no. 1) type on the Jaeger test chart, as arranged by Dr. S. Lewis Ziegler, to letters 3 inches (7.5 cm) in height.

If the lessons were given slowly, as they were, it was interesting to note that the fact that the patient remembered the targets was not a handicap. The letters on the target were then studied more carefully, and possibly an inherent inferiority complex was overcome, with resultant cooperation on the part of the patient.

#### TECHNIC OF USING THE TELESCOPIC AMBLYOSCOPE

The device may be used in one of two ways. With either method the  $-2.00$  D sphere (*B*, figure 1) is placed before the eyepiece if the reading target is inserted at the 1 meter distance, or the  $-6.00$  D sphere is used without targets for reading at 20 feet or more. The visual correction is worn by the patient.

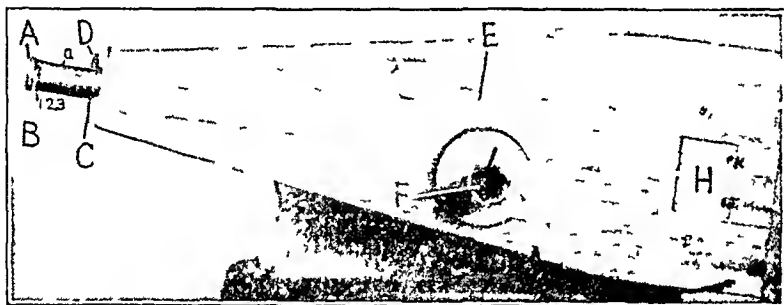
With method 1, the handle (*F*), which actuates the objective (*E*) is placed at 8 or 10. This signifies a distance of 8 or 10 inches (20 to 25 cm) from the eyepiece. The lever (*D*) operating the lens in the eyepiece is then moved from 0 to  $1\frac{1}{2}$  on the scale (*a*), denoting the distance in inches (1.5 to 3.75 cm) from the movable lens (*C*) to the fixed lens (*A*), contained in the eyepiece. Occasionally while the patient is reading, he may note a blur. This indicates ocular suppression, which is improved by pressing several times quickly on *D*, which moves lens *C* up and down, thus overcoming the blurring. It is best to continue using targets of progressively smaller type. Photomicrographic newspapers, such as were sent overseas during the recent war, were found most satisfactory. (The topics were interesting, and the type was minute as seen at a distance of 1 meter.)

With method 2, the technic is the same as in the method just described except that the lever (*F*), after good vision is obtained by the patient, is moved back and forth to obtain first clear and then poor vision, an exercise to stimulate the eye to better vision by means of accurate focusing.

During the lesson a certain amount of time was devoted to overcoming any other visual obstacle present in addition to amblyopia. At the first evidence of fatigue during the visual training the lesson was stopped, and the rest of the lesson period was devoted to overcoming the obstacles present by treatment with the synoptophore, the cheiroscope, the rotoscope or any other device deemed advisable by the technician.

#### PLAN OF STUDY

At the first examination each patient had his vision taken on three types of test charts, usually the Snellen E chart for illiterate persons and the letter and number charts.<sup>4</sup> As is well known, certain letters are more easily read than others. Ordinarily, letters or numbers, as demonstrated in the "Manual of the Medical Department" by Lebensohn<sup>5</sup> are more difficult to discern. For example, an 8 looks more like *B*, *P*, or *T*, are misread for the letter *F*, and *D* looks like *B* or *O*. It was observed that discrimination is easier with the white letters on a black background.



Telescopic amblyoscope

*A*, a  $-11.00$  D sphere permanently fixed, *B*, a sliding lens holder, containing (1) a  $-2.00$  D sphere, (2) an open space for inserting a lens of any diopter strength for experimental purposes and (3) a  $-6.00$  D sphere, *C*, a  $+6.00$  D sphere operated by holder *D*, in the center of which is a rod which moves lens *C*, and thus may be used to overcome suppression while giving the lesson, *a*, an engraved plate to give the exact distance of *C* from *A*, *D*, holder for the  $+6.00$  D sphere (*C*), which effects its movement, *E*,  $+3.00$  D sphere, the objective of the telescope, *F*, dial giving the distance of the objective from the ocular, *G*, target holder, and *H*, trapdoor used by the technician to view the target and indicate where the patient should fix his attention.

To make certain that the test charts were not memorized, a large variety of charts were utilized in checking the visual acuity.

As in orthoptic training, there was great difficulty in making appointments. Children, with few exceptions, could be seen only after school hours, from 3:30 to 5 p. m., and on Saturdays between 9 a. m. and 1 p. m. For adults the convenient time was the lunch hour, from 12 to 1 p. m., and the Saturday morning hours. It should be remembered that, as in orthoptic training, the best results are obtained in the early hours of the day, when the child is not fatigued. For

<sup>4</sup> The illumination of the chart was 70 foot candles, evenly distributed over the entire chart.

<sup>5</sup> Lebensohn, J. E. Visual Rating, and Presentation of Improved Unlearnable Letter Chart, U. S. Nav. M. Bull. 41 744, 1943.

this reason some of the patients were induced to come during school hours. In a few instances the teacher was cooperative in this venture and permitted the child's absence from school. The improvement in vision in these cases was gratifying.

Lessons were given once a week, lasting about one-half to three-quarters hour, depending on the cooperation of the patient. It was also found that, as in orthoptic treatment, a lesson lasting much longer fatigued the patient. In this group it was generally found impossible to get the patient to come oftener than once a week.

After the patient had been given twelve lessons (one a week), he was given a period of rest of one month. On the patient's return, after one month, the vision of both eyes was taken. This temporary interval between lessons was to make sure that the improved vision of the previous series of lessons was retained. If vision was not normal,<sup>6</sup> it was again taken through the telescopic amblyoscope with the Snellen test chart as a target at 20 feet (6 meters), just as was done before the first series of twelve lessons was given. If vision still showed possibilities of improvement, another series of twelve lessons was suggested. Any improvement, if obtained, came within these two series of lessons. The improvement obtained during a third series of twelve lessons was so slight that it hardly deserved the time and trouble taken. Unfortunately, a few patients included in this series who attained a 20/30 vision could not be persuaded to complete the course of treatment to attain 20/20 vision. Usually refusal was ascribed to illness in the family, distance to be traveled for lessons or inconvenience of time of appointment. However, these patients were asked to return regularly for a recheck of vision, which always remained constant. With few exceptions, all the patients who came for lessons kept their appointments regularly.

Ordinarily, one should see some improvement in vision at the end of the fifth to the seventh lesson. In some cases the rate of progress was accelerated at this time. Patients whose vision did not improve after the seventh lesson were advised to discontinue treatment, particularly if their attendance was irregular. Defects such as suppression, lack of simultaneous macular perception, poor fusion or stereopsis, were treated in conjunction with the amblyopia.

Home work was given to a few patients. This consisted in placing the patient 20 feet from a visual acuity chart and patching the good eye. Glasses were required to be worn. The subject stepped forward to the greatest distance at which the smallest type of the E chart for illiterates was just visible to him, then slowly stepped backward to see whether this line could be retained. When this line was mastered at 20 feet, an attempt was made to study the line of next smaller type on the test chart. The E or the broken ring chart is most suitable for this type of work, since by cutting the chart in half and turning it on its four sides eight different test charts are obtained. The individual chart in different positions is difficult to memorize. As stated previously in regard to targets, even if a patient remembers the letters of a chart, the success of the home training is not materially affected. To obviate fatigue, only five minutes of this home instruction should be given at a time. The exercise may be repeated after several hours. Continuous patching of the good eye was prescribed for a few patients, but it is questionable how adequately this treatment was carried out.

#### PROGNOSIS

The prognosis of amblyopia has always been difficult to make. Pugh<sup>7</sup> claimed that it was impossible to make a prognosis of the result

<sup>6</sup> All patients' vision was taken with the glasses on.

<sup>7</sup> Pugh, M. A. *Squint Training*, London, Oxford University Press, 1936, p. 39.

of treatment in any case of amblyopia. It was found in a previous study with the Wollensak Allscope<sup>1</sup> that little could be expected by way of treatment from patients who did not have vision of 20/70 on the Snellen chart.

A patient whose vision was no better than 20/100 while looking through the telescopic amblyoscope was considered as possibly having congenital amblyopia. Such patients were not regarded as amenable to treatment. However, in spite of this, a few such patients were given visual training by way of experiment, with the expected poor result. Usually the initial vision taken through the telescopic amblyoscope with the Snellen chart at 20 feet was the final vision, plus or minus one line on the test chart, a change which one could expect the patient would show after his twelfth lesson with the wearing of glasses. This improvement occurs provided there is not absolute suppression. When there is pronounced suppression, it is best to attempt a correction of this condition before a definite prognosis is made. Often exercises given for one eye improved the sight of both eyes. This was also true of suppression in one eye. Improvement in vision was usually associated with improvement in suppression.

#### REVIEW OF CASES

The total series of patients taking treatments was 47. The ages varied from 6 to 46 years. Of the patients studied, those from 6 to 38 years of age showed the most promising results. Altogether, 56 patients were studied, 9, after preliminary studies were completed, could not return, for such reasons as inconvenience of clinic hours and illness, they therefore are not included in the present series.

Of the 47 patients, the majority, 34, or 72 per cent, ranged in age from 6 to 15 years, inclusive. It was interesting to note that in this small series there were 33 males and 14 females. Vision was defective in 14 right eyes and in 25 left eyes, and in 8 patients both eyes were ametropic. All the eyes, of course, had normal fundi. Twenty-five patients had anisometropia, all of whom obtained improvement in vision, except for 1 who showed no improvement whatever, and 2 who showed questionable improvement. Two patients had no refractive error.

Two trained technicians took care of the patients and interchanged patients in treatment, so that an error in judgment concerning the treatment of a particular patient would less likely be made. Five patients took two series of twelve lessons each, with a period of rest of four or five weeks between the two series. Two patients took a third series of lessons, like the preceding group, they had a rest period of four or five weeks before beginning each new series.

One patient, J. B., case 7, had improvement in vision but vision was extramacular, so that this patient, even though the vision improved from 20/200 to 20/40, could not be said to have improvement in vision<sup>8</sup>

Unfortunately, the school vacation period came on before treatment of all the patients was completed, and 10 patients discontinued treatment. Of these 10 patients, 5 (cases 9, 11, 15, 40 and 47), showed definite improvement and were well on the way to emetropic vision. Five patients (cases 14, 21, 32, 43 and 45) did very poorly, possibly because of irregular attendance, and they were advised to discontinue the treatment. The oldest patients who showed improvement were M. L., (case 24), aged 40, and A. H. (case 22), aged 37 (table 1)

*Suppression*—In the case of C. F. (4), the suppression became milder at the end of the second series of twelve lessons, and in the case of J. G. (6), the suppression entirely disappeared during the second course of lessons. In some of the patients examined suppression continued, yet vision improved in spite of this. For example, in cases 9, 15, 16, 29, 30 and 37 unilateral suppression changed to alternating suppression. Vision improved in all these cases. Often both the vision and the suppression improved to the same degree. In cases 16 and 37 vision improved more than the suppression.

In 3 patients with alternating suppression the results of treatment were as follows. F. S. (case 45) showed no improvement in vision or in suppression; R. E. (case 21) exhibited slight improvement in suppression with notable improvement in vision, and in J. K. (case 35) the alternating suppression became unilateral suppression with decided improvement in vision.

The other patients with alternating suppression (cases 10, 24, 25, 26, 31, 35 and 46) showed improvement in vision after taking lessons.

*Fusion*—Thirty-seven patients had fusion before they came for treatment. One patient never obtained fusion. One patient obtained fusion at false projection. The remaining 8 patients obtained fusion in from two to eight lessons.

*Stereopsis*—Twenty-nine patients had stereopsis before they began visual training. Of the remaining 18 in the series, only 10 patients had

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<sup>8</sup> A case similar to case 7, that of M. K., a woman aged 61, was not included in this series because of the patient's age, and particularly because of the ocular condition, which was such that little could be expected from any treatment. The patient had rotary nystagmus, right convergent squint of 45 degrees and palsy of the inferior oblique and superior rectus muscles. Vision was equal to light perception in the right eye and 6/300 in the left eye. After several irregularly taken lessons, vision in the left eye improved to 12/300. She also felt that the nystagmus was less. She was enthusiastic about her improvement in vision, saying that she could see the cracks in the sidewalk and that the curb was more clearly visible. Since she was so enthusiastic about the treatment, it was deemed unnecessary to explain to her that although the treatment was partially successful the improvement was not of the kind desired, that it might represent extramacular vision.

questionable stereopsis at the completion of training, and the other 8 obtained stereopsis in from five to twelve lessons

*Amisometropia*—There were 24 patients with anisometropia in this group. In 19 of these patients the condition improved. Three showed a questionable improvement, and 2 had no improvement whatever.

TABLE 1—*Resume of Clinical Data on Forty-Seven Patients Treated with the Telescopic Amblyoscope*

Case No	Name	Sex	Vision Before Treatment	Vision After Treatment	Total No of Lessons
1	L A	M	20/100	20/30	24
2	J S	M	20/50	20/30	34
3	W S	M	20/200	20/50—	24
4	O F	F	20/200	20/50	24
5	O B	M	20/100	20/40+	12
6	J G	M	20/70	20/20—	22
7	J B	M	20/200	20/40—	31
8	R P	M	20/200	20/40—	24
9	S B	M	20/40	20/20—	7
10	S L	M	20/70 20/70	20/40 20/40	12
11	H M	M	20/50+	20/30	7
12	E L	F	20/70	20/50—	9
13	W L	M	12/200	20/100	12
14	R L	M	10/200	10/200	7
15	P L	F	20/50	20/30	11
16	C M	M	20/40	20/30+	12
17	J S	M	20/100	20/50+	12
18	H S	M	20/70	20/30	12
19	B E	M	20/300	20/100+	7
20	J C	M	20/70	20/40—	12
21	R E	M	20/70 20/70	20/30— 20/30—	12
22	A H	M	20/70+	20/40+	12
23	A K	M	20/70	20/40+	12
24	M L	F	20/50— 20/50+	20/40 20/40	12
25	R R	M	20/100	20/50	12
26	L M	M	20/70 20/70	20/40 20/50+	12
27	H Y	M	20/100	20/40	12
28	W S	M	20/100	20/40—	12
29	W S	M	20/100	20/50	12
30	I S	F	20/70	20/50	12
31	B L	F	20/200	20/100	12
32	B K	M	20/100	20/200	10
33	T P	F	20/40	20/20—	12
34	J A	M	20/70	20/50+	12
35	J R	F	20/50+ 20/50	20/30+ 20/30+	12
36	J K	M	20/100	20/40+	12
37	G J	M	20/50 20/50	20/30 20/30	12
38	F C	F	20/50	20/30+	12
39	D K	M	20/70	20/20—	4
40	B B	F	20/50+	20/30—	5
41	I E	F	20/50	20/20—	12
42	R M	M	20/70	20/40	12
43	R P	F	20/200	20/148	8
44	A C	F	20/50—	20/40+	6
45	F S	M	20/70 20/70	20/100 20/70	12
46	B G	F	20/70+	20/40—	12
47	H R	M	20/70	20/40	5

#### OBSERVATIONS BY PATIENTS

Clinically, a few of the patients felt better subjectively and volunteered information, as follows:

L A (case 1), aged 15, claimed to have "greater visual comfort" after the first course of twelve lessons.

J G (case 6), aged 7, said he had better visual comfort and that the "spot" he could not see through when looking ahead was "no longer there."

S L (case 6), aged 9, with lateral nystagmus, saw the blackboard better in school, felt more comfortable and was told that his eyes did not "shake as much"

L M, (case 26), aged 26, with lateral nystagmus, said that "the pain in the back of the head and the general discomfort disappeared during the first course of twelve lessons" He was told by several members of his family, one a physician, that the lateral movements of his eyes were not so frequent

G J (case 37), aged 9, who always had headache, said he "feels better in school"

R M (case 42), aged 8, said that "the pains and funny feeling" in his head had disappeared

TABLE 2—Detailed Clinical Data on Four Patients Treated with the Stereoscopic Amblyoscope

Case No., Name, Age, Sex	Vision	Lesson No	Vision Before Treatment, Left Eye	Progress	Vision After Treatment, Left Eye
6†	Vision with correction	1	20/70	Suppression	20/70
J G	R L 20/0 with +3.25 sph C	2	20/60+	in left eye	20/50
7	+1.50 cyl, ax 90	3	20/10—	noted	20/10—
M	L 1 20/70 with -3.00 sph C	4	20/10—	throughout	20/10
	+1.50 cyl, ax 105	5	20/10—	early,	20/10+
	Blindspot slightly enlarged on	6	20/30—	stereopsis	20/40+
	study of fields	7	20/30	obtained	20/10+
	Vision in L 1 20/0 with stereo	8	20/30	and kept	20/30+
	scope amblyoscope at 6 meters	9	20/30+		20/30+
	Fusion present	10	20/30		20/30+
		11	20/30+		20/30
		12	20/30		20/30+
15‡	Vision with correction	1	20/10—	Strong sup	20/10
P L	R R 20/0 with +5.50 sph C	2	20/40—	pression in	20/10
7	+0.25 cyl, ax 90	3	20/10—	L 1 fusion	20/30
I	L 1 20/70 with +6.00 sph C	4	20/30	obtained,	20/30
	+1.00 cyl, ax 90	5	20/30+	suppression	20/30
	With amblyoscope at 6 meters	6	20/30+	now alternat	20/30+
	vision in L 1 20/30	7	20/30+	ing and con	20/30+
	S M P † fusion obtained on	8	20/30+	tinued as	20/30+
	third lesson	9	20/30+	such with	20/30+
		10	20/30+	improvement	20/30—
		11	20/30+		20/20+
		12	20/30+		
19§	No refractive error present	1	20/300	No suppression	20/200
B L	R R 20/30	2	20/300	noted,	20/200
16	L E 20/30, vision of 20/100 ob	3	20/200	stereopsis	20/200
M	tained with stereoscopic amblyo	4	20/200	very poor	20/200
	scope	5	20/100—		20/100
	No suppression present in spite	6	20/100—		20/100
	of high visual error	7	20/100		20/100+
	Fusion present				
	Attendance irregular, lessons				
	discontinued				
43	Vision with correction	1	20/200	Began with	20/200
R P	R L 20/20 with +1.00 sph C	2	20/200	complete	20/148
46	+0.25 cyl, ax 90	3	20/200	suppression	20/148
F	L E 20/200 with +1.50 sph C	4	20/148	of left eye	20/148
	+5.00 cyl, ax 90, add +2.25	5	20/110		20/100—
	Temporary fusion	6	20/200+		20/148
		7	20/200		20/100
		8	20/148		20/148

\* A complete table of data for the entire series of patients treated will be furnished by the author on request

† The patient took twenty two lessons. Note the gradual improvement in vision with succeeding lessons. Suppression was present up to the seventeenth lesson

‡ The patient had strong suppression, which changed to the alternating type. Vision improved in spite of this

§ S M P indicates simultaneous macular perception

|| The patient had vision of 20/300 but no suppression. Vision at the seventh lesson did not improve to better than 20/100, and treatment was discontinued

|| The patient, aged 46, had complete suppression, which improved. Vision did not improve, and treatment was discontinued after the eighth lesson. Presbyopic patients whose vision is checked on the telescopic amblyoscope at 20 feet (6 meters) get vision unobtainable with visual training. This was noted in 2 other patients. R P had vision of 20/30 at 20 feet (6 meters) with the device



## COMMENT

The question naturally asked is, "How can training help the vision?" Lancaster's explanation<sup>9</sup> for this improvement in visual acuity can be logically applied to this form of visual training, a method which is scientific and accepts acknowledged ophthalmologic data. He expressed the belief that it is not the primary retinal sensation that is improved, "it is the neglected but vitally important cerebral part of seeing that has been trained." Dobson's opinion<sup>10</sup> on the improvement of squint went further but can also be applied to the visual improvement obtained in treatment of ametropia. She expressed the belief that the improvement is explained by an arrest of development either in the macula lutea or in the occipital cortex, or in some intermediate area. The improvement obtained with the type of visual training reported here is compatible with the aforementioned theories. Whatever may be the explanations for the cause of success in ocular training, the fact is that visual training has often been successful in the hands of ophthalmologists. Travers<sup>11</sup> has used reading exercises to improve the visions of applicants for the air service with some success.

Although the present series is too small for statistical purposes, certain generalities can be made as to the value of visual training with the telescopic amblyoscope in cases of defective vision. An attempt will be made to follow up these patients from time to time to determine the permanency of the improvements obtained.

It was noted that although the improvement in vision was not startling it was usually consistent and ever increasing, with few exceptions, from lesson to lesson (table 2). Examination after an interval of four weeks or slightly more with no visual training following a course of twelve lessons showed that the improvement in vision after the series of treatments was usually retained.

Suppression was found to be commonly present in persons with refractive errors, but improvement in vision after training was often accompanied with disappearance of the suppression. In 4 patients, however, the suppression never improved and vision did not improve either.

The magnification of the target and the fine focus adjustment of the apparatus probably help the patient in overcoming his timidity and should aid him psychologically in cooperation toward bettering his vision.

The visual correction originally obtained with glasses must continually be made use of.

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9 Lancaster, W. B. Present Status of Eye Exercises for Improvement of Visual Functions, *Tr Am Acad Ophth* (1943) 48:413, 1944.

10 Dobson, M. *Binocular Vision and the Modern Treatment of Squint*, New York, Oxford University Press, 1933, p. 29.

11 Travers, T. a' B. Distinction Between Amblyopia and Organic Defects of Vision, *Tr Ophth Soc Australia* (1941) 3:82, 1942.

Visual training prevents the embarrassment which children usually suffer when the good eye is continuously patched

Whether the improvement in vision is proportional to the number and frequency of the lessons received is not possible to state at this time. During next winter's course of treatments an attempt will be made to give some cooperative patients three lessons a week in order to determine the relative benefit obtained

Anisometropia was no more difficult to cure than the high hyperopias or myopias. Some patients with 20/40 vision were more difficult to train than patients with anisometropia

#### SUMMARY

An instrument, the telescopic amblyoscope, which can be used for prognosis and for the training of defective vision in patients with ametropia of various intensities, is described

Forty-seven patients with intractable ametropia were given reading lessons using the instrument. The technic of training for improvement of vision is described

A prognosis is made by having the patient look through the telescopic amblyoscope at a test chart 20 feet (6 meters) away. Vision thus obtained, plus or minus one line, is the final vision to be expected after twelve lessons.

The reading lessons were given once a week for twelve weeks, then patients were given a rest period of four to five weeks to see whether the visual improvement after the last lesson was retained

If after the rest period another examination gave promise of the vision being further improved, another series of twelve lessons was given. Little improvement was obtained after the second series of lessons

The visual fields were found to be of neither diagnostic nor prognostic value

The role of suppression in cases of amblyopia is discussed. Only in cases in which the suppression is severe (or absolute) should this defect be overcome before a prognosis for the amblyopia is given. Milder suppression may be overcome or even remain unimproved and yet the visual acuity may become improved

The degree of the initial visual acuity is not necessarily an index to the prognosis in the case. Ametropia with vision of 20/40 may be more difficult to treat than anisometropia

A table is presented showing the number of patients, the number of lessons given and the initial and terminal vision of each patient, as well as a table showing the refractive error and weekly progress in each of 4 cases

## NATURE OF GLAUCOMA

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GLAUCOMA is a condition in which the intraocular pressure is intermittently or continuously higher than the optimum pressure which the organism has developed as a physiologic norm. The chief problem which this condition presents is the means by which the intermittent or continuous increase in intraocular pressure is brought about. Assuming that there is an acceptable theory which explains the manner in which the increase in pressure is brought about, how do the various clinical forms of glaucoma fit such a theory?

In a publication in 1938,<sup>1</sup> I presented a new concept of the maintenance of normal intraocular pressure and a new theory of the pathogenesis of chronic simple glaucoma. In the following discussion, I shall restate (1) the concept of the maintenance of normal intraocular pressure, and (2) the theory of the manner in which an increased intraocular pressure is brought about. I shall then attempt to show how the various forms of glaucoma fit such a theory.

### MAINTENANCE OF NORMAL INTRAOCULAR PRESSURE

Normal intraocular pressure is maintained within narrow limits of variation. As presented in my previous publication, I conceive it to be maintained by means of a mechanism consisting of an effector organ within the eye and a central regulating apparatus. The latter consists of a center in the brain which regulates the activity of the effector organ through a neural and, possibly, a hormonal control. Such a mechanism must be assumed for the maintenance of each and every one of the physiologic norms within the organism, including the normal intraocular pressure. The manner of the working of this mechanism can perhaps be clarified.

*Effector Organ*—In 1938 I said

The effector organ for the maintenance of the normal intraocular pressure consists of at least three units: (1) the capillary walls and the walls of Schlemm's canal, the passage of fluid through which is regulated by the electrolytic content of its layers, (2) the amount of circulating aqueous, and (3) the amount of circulating blood.<sup>1</sup>

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<sup>1</sup> Elwyn, H. Pathogenesis of Chronic Simple Glaucoma, Arch. Ophth. 19: 986 (June) 1938.

In the containing, practically inelastic sclerocorneal coat the intraocular pressure is maintained by the aqueous in the chambers of the eye and by the blood in the vessels of the uvea, especially those of the choroid. The amount of aqueous within the chambers and the amount of blood within the choroidal vessels are normally of a certain definite quantity, just sufficient to maintain the normal pressure. The volume of aqueous is kept within bounds by the balance between production and outflow, and such a balance is primitively regulated by the constellation of electrolytes in the separating membranes through which fluid (aqueous) moves into the posterior chamber and out through the angle of the anterior chamber and Schlemm's canal. Little is known about the regulating electrolytes, but, in analogy with other membranes of the body through which fluid moves, there is no doubt that such a primitive regulation exists. When, for any reason, the volume of aqueous increases or diminishes, the change of pressure on the transmitting membranes causes the additional central regulation to act in reestablishing the normal quantity.

Similarly, the volume of blood within the vessels of the choroid is of a definite quantity and is maintained within these vessels in just sufficient quantity to help, with the aqueous, in maintaining normal intraocular pressure. Here, also, any increase or decrease is immediately counterbalanced by the primitive regulating mechanism of electrolytes within the choroid, and more definitely by the central regulation. The result is the continuous maintenance of a definite volume of blood within the vessels of the choroid, which, with the constant volume of the aqueous, maintains the continuous normal intraocular pressure.

There are, then, in the effector organ for maintenance of the intraocular pressure three parts, or units, (1) the site of production of the aqueous, for the greater part the ciliary body, (2) the site of outflow of the aqueous, for the greater part the angle of the anterior chamber with Schlemm's canal, and (3) the blood vessels of the choroid. The importance of these three units in the maintenance of normal intraocular pressure is shown by certain pathologic conditions which involve separately each of these units.

- 1 The importance of the ciliary body in production of the necessary quantity of aqueous is shown in the lowering of the intraocular pressure when the ciliary body is diseased, as in inflammation, or when it is partly destroyed.

- 2 The importance of the angle of the anterior chamber in the outflow of the aqueous is shown by the sudden rise in the intraocular pressure when the angle is suddenly obstructed. Such an obstruction may be produced by a dislocated lens in the anterior chamber or by the filling of the angle with herniated vitreous, the latter being an occasional complication after extraction of a cataract within the capsule.

3 The importance of the choroidal vessels for maintenance of the intraocular pressure is shown by an experiment which nature occasionally performs. In cases of nevus flammeus of the face associated with glaucoma (part of the Sturge-Weber syndrome) there is an increase in the intraocular pressure. Before secondary changes due to the increased intraocular pressure have occurred, there are no pathologic changes in the angle of the anterior chamber, in the ciliary body or anywhere in the eye except in the choroid. Here, there occurs a thickening due to an angioma, consisting of dilated spaces with very thin walls, which are lined by endothelium and filled with blood. The appearance is that of a cavernous angioma. In such cavernous spaces the constant volume of blood, which should not exceed that necessary to help maintain the intraocular pressure, cannot properly be regulated, and the result is an increase in intraocular pressure.

*Central Regulation*—In 1938 I stated

Nothing is known of any center in the brain which controls the maintenance of intraocular pressure. In spite of this, it is necessary to hold to the conviction that there is such a controlling center. [It] would probably be located in the brain stem, in the gray matter surrounding the canal system, where so many of the centers for vegetative functions are located. The considerations which lead me to assume the existence of such a center mainly are (1) the analogy with other vegetative functions which are known to be controlled by a center in the brain, (2) the inadequacy of the assumption that the action of purely physical forces alone and without regulation can explain the maintenance of such a physiologic constant as the normal intraocular pressure, and (3) the independence of the maintenance of the normal intraocular pressure from other bodily functions.

These considerations still hold good.

*The Means of Control*—I have assumed, in analogy with other vegetative functions, that the means of control are hormonal and neural. For control by means of any hormone derived from any gland of internal secretion, there is at present no evidence whatever. There is evidence for control by means of nerves.

*Neural Control*—I have said that the units in the effector organ for the maintenance of intraocular pressure are (1) the angle of the anterior chamber, (2) the ciliary body and (3) the blood vessels of the choroid. These units receive their nerve supply from the parasympathetic ciliary ganglion, from which the short ciliary nerves leave as postganglionic fibers to enter the uvea. Their preganglionic fibers are contained in the oculomotor nerve and originate in the small-celled Edinger-Westphal nucleus, in the midbrain. The postganglionic fibers terminate in the tissues of the angle of the anterior chamber, in the ciliary body and in the choroid and its vessels. Convoluting myelinated and nonmyelinated fibers are to be seen in the intervascular tissue of the choroid and the ciliary body. It can be assumed that these nerve fibers

serve the regulation of the functions of the choroidal vessels, of the ciliary body and of the tissues of the angle of the chamber. According to Eisler,<sup>1a</sup> the nerve supply of the choroid, including its vessels, is derived from the short ciliary nerves only

The ciliary ganglion receives also a sympathetic root, which enters into relation with the parasympathetic fibers from the ciliary ganglion. It is possible that the eventual termination of the sympathetic fibers is as vasomotor fibers in the uvea. However, it is definitely established that vasodilator fibers for the eye run in the fifth nerve, according to Abderhalden,<sup>2</sup> who cited the literature on this subject. These fibers possibly run in the nasociliary nerve, which is a branch of the ophthalmic nerve, and from which a branch joins the ciliary ganglion as a long root. While the character of the nerve fibers in the sympathetic root of the ciliary ganglion and that of the fibers in the root derived from the nasociliary nerve are not definitely established, the character of the fibers which leave the ciliary ganglion in the short ciliary nerve as postganglionic fibers, and which originate in the cells of the ciliary ganglion, is definitely known. They are cholinergic and belong to the parasympathetic system. This points to a parasympathetic control of the functions of the choroid, of the ciliary body and of the angle of the anterior chamber, with its venous system. It also points to a parasympathetic control of the intraocular pressure.

#### MEDIATION OF ACETYLCHOLINE AND EFFECT OF PHYSOSTIGMINE

Further evidence that control of the intraocular pressure is by means of the cholinergic nerves of the parasympathetic system is given by the known action of physostigmine. The original studies of Otto Loewi and the work of all the investigators who followed in his steps have established that nerve fibers exercise their influence on effector cells by means of chemical mediators. It is known that the chemical mediator of the postganglionic fibers of the parasympathetic system is acetylcholine, which is produced at the nerve endings and which acts on the effector cells. It is known that acetylcholine is quickly destroyed by the specific enzyme cholinesterase, present in the blood and tissues of the body, which splits it into choline and acetic acid. The action of choline is weak compared with that of acetylcholine. Physostigmine in low concentration inactivates cholinesterase by combining with it, and in this manner permits the acetylcholine to act longer and more intensively.

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1a Eisler, P. Die Anatomie des menschlichen Auges, in Schieck, F., and Brückner, A. Kurzes Handbuch der Ophthalmologie, Berlin, Julius Springer, 1930, vol 1, p 70

2 Abderhalden, E. Lehrbuch der physiologischen Chemie in dreissig Vorlesungen, ed 1, Berlin, Urban & Schwarzenberg, 1925, vol 2, p 317

Although acetylcholine is quickly destroyed in the tissues, the possibility of its being found within the eye has been thought of. Velhagen<sup>3</sup> demonstrated the "parasympathetic stuff" of Loewi, which is identical with acetylcholine, in the aqueous of certain animals. Engelhart<sup>4</sup> instilled physostigmine into the eye of rabbits to prevent the destruction by cholinesterase of any acetylcholine present and then exposed the eyes to light for parasympathetic stimulation. Under these conditions, he proved the presence of acetylcholine in the aqueous. Bloomfield<sup>5</sup> attempted to determine quantitatively the acetylcholine content of the aqueous of human eyes prepared according to the method applied by Engelhart to rabbit eyes. He tested 10 eyes with various noninflammatory pathologic conditions, but without glaucoma. The aqueous of each of the 10 eyes produced an inotropic depression of the heart beat. In 8 of the experiments the intensity of this effect was approximately equal to that produced on the same heart by a similar amount of acetylcholine in 1:100,000,000 dilution. In the remaining 2 essays the effect was one which could be reproduced with known concentrations of acetylcholine of over 1:1,000,000.

These studies leave no doubt that stimulation of parasympathetic fibers of the eye leads to the production of acetylcholine in the eyes, which then overflows in the aqueous when its destruction is prevented by physostigmine.

In the early stages of chronic simple glaucoma, before any secondary organic changes have occurred in the eye, the intraocular pressure is increased at various times and is normal at others. In the period of increased intraocular pressure, the instillation of physostigmine into the conjunctival sac lowers the intraocular pressure to normal. With the known action of physostigmine, it is obvious that with inactivation of cholinesterase any acetylcholine present is permitted to act on the cells of the effector organ.

Here is definite evidence that the intraocular pressure is regulated by nerve impulses mediated by acetylcholine. The question is: Where do the nerve impulses originate? Obviously, not in the nerve endings or in the nerve fibers, for nerve impulses originate only in nerve cells. Do the nerve impulses for the regulation of intraocular pressure originate in the cells of the ciliary ganglion? Assuredly not! It has been pointed

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3 Velhagen, K., Jr. Zur Frage der vagotropen Substanzen im Auge, *Arch f Augenh* **105** 573, 1932.

4 Engelhart, E. Der humorale Wirkungsmechanismus der Oculomotoriusreizung, *Arch f d ges Physiol* **227** 220, 1931.

5 Bloomfield, S. Parasympathomimetic Effect of Aqueous Humor in Human Eyes With and Without Chronic Simple Glaucoma, *Proc Soc Exper Biol & Med* **60** 293, 1945.

out by Gaskell<sup>6</sup> that the peripheral ganglions of the autonomic nervous system, to which the ciliary ganglion belongs, are intermediary relay stations, and purely distributive in character. They are definitely not regulative, but continue the propagation of impulses received from the preganglionic fibers. These preganglionic fibers are contained in the third nerve and are derived from the cells of the Edinger-Westphal nucleus. Impulses for the regulation of the intraocular pressure must, therefore, originate in the cells of the Edinger-Westphal nucleus, or in some center in the brain close by which sends impulses to the cells of the nucleus.

It is apparent from this discussion that there is evidence of a central regulation of the intraocular pressure and that such a regulation is effected by means of the parasympathetic fibers of the third nerve, mediated by acetylcholine, which acts on the cells and tissues of the effector organ in the eye.

#### SUMMARY

I conceive the mechanism for maintenance of normal intraocular pressure to be as follows:

1. There is a unit mechanism consisting of an effector organ within the eye and a central control from a center in the brain mediated by means of cholinergic nerves of the parasympathetic nervous system.

2. Normal intraocular pressure is maintained within the containing sclerocorneal coat by means of a constant definite volume of aqueous in the chambers of the eye and of a constant definite volume of blood in the vessels of the choroid.

3. The effector organ for the maintenance of intraocular pressure consists of three units: the tissues of the angle of the anterior chamber with Schlemm's canal, the ciliary body and the vessels of the choroid.

4. The constant volume of aqueous is maintained by the activity of the ciliary body and that of the angle of the anterior chamber, with its venous system. A primitive regulation is maintained in these tissues by means of a constellation of electrolytes. These tissues form one arm of the effector organ.

5. The volume of blood in the vessels of the choroid is regulated by the walls of the vessels. Here, also, a primitive regulation is maintained by means of electrolytes. These vessels form the second arm of the effector organ.

6. The primitive peripheral regulation is not sufficient in the highly developed warm-blooded animal. As in all vegetative functions in such animals, the primitive peripheral regulation is superseded by a central regulation.

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<sup>6</sup> Gaskell, W. H. *The Involuntary Nervous System*, London, Longmans, Green & Co., 1920.



7 Central regulation is effected from a center in the brain, probably situated in the brain stem near or in the Edinger-Westphal nucleus

8 From this center, impulses are propagated by way of the pre-ganglionic fibers to the cells of the ciliary ganglion. Here they are redistributed and are propagated by means of the fibers of the short ciliary nerves to the tissues of the angle of the anterior chamber and its venous system, to the ciliary body and to the vessels of the choroid

9 At their nerve endings the impulses are mediated by means of acetylcholine, which acts on the cells and tissues of the three units of the effector organ

#### HOW IS THE INTERMITTENT OR CONTINUOUS INCREASE IN INTRAOCULAR PRESSURE BROUGHT ABOUT?

With the understanding of the mechanisms for the maintenance of normal intraocular pressure, the chief problem can be attacked. How is the intermittent or continuous increase in intraocular pressure brought about?

For the intraocular pressure to be continuously increased there must be an increase in the constant volume of the aqueous, or an increase in the constant volume of the blood in the vessels of the choroid, or an increase in both. Such an increase can be conceived to be produced (1) by organic changes and (2) by functional means

1 Organic changes can produce an increase in the constant volume of the aqueous by interfering with its outflow. Such interference is produced by dislocation of the lens into the anterior chamber, by clotted blood or herniated vitreous filling the anterior chamber, by organic changes in the angle of the anterior chamber, such as follow obstruction of the central vein in some cases, by anterior synechias, such as occur in the later stages of glaucoma, by iris bombé and by a tumor or an exudate so situated as to obstruct the angle of the anterior chamber

An increase in the constant volume of the blood in the choroidal vessels can be brought about by organic changes in the character of the vessels, such as an angiomatous malformation, or by any tumor, mass of blood or exudate which interferes with the outflow of blood from the choroidal vessels

All these organic changes cause an increase in the intraocular pressure, which is usually referred to as secondary glaucoma

2 An increase in the constant volume of the aqueous by functional means, in the absence of any organic changes in the eye, can be conceived to be produced by an increase in the production of the aqueous or by a diminution in its outflow. Such a change would mean a breakdown in the primitive electrolytic regulation of the effector organ. However, such a functional change, while it may occur for a moment, calls

at once for a counterbalancing influence by the central regulation over the neural pathways and the chemical mediator acetylcholine. In the presence of a normal central regulation, such a peripheral functional change which would result in an intermittent or a continuous increase in the intraocular pressure cannot be assumed.

Similarly, an increase in the volume of blood in the vessels of the choroid due to a peripheral functional change cannot be assumed to result in an intermittent or a continuous increase in intraocular pressure as long as the central regulatory apparatus is functionally intact.

*Functional Change in Central Regulation.*—In the absence of any organic changes in the eye, and with the units of the effector organ intact, an increase in intraocular pressure can be conceived as due to a functional change in regulation. Such a change would mean that the chemical mediator acetylcholine, which exerts its influence on the cells of the effector organ, is not produced in the continuous amounts necessary to maintain the continuous normal intraocular pressure. Instead, it would indicate that the production of acetylcholine is irregular, at times in normal amounts, at times in diminished amounts and at times in such small quantities that the intraocular pressure would remain continuously high.

Three possibilities present themselves. 1 A functional change at the nerve endings, where the acetylcholine is produced. This possibility is not acceptable, for any diminution in acetylcholine must at once call into activity the regulating center. 2 A functional change in the ciliary ganglion. This possibility, also, is not acceptable as long as the regulating center is intact, for the ciliary ganglion is only a relay station for the impulses coming from the preganglionic fibers and the center of regulation. 3 A functional change in the center of regulation. This is an acceptable possibility and to my mind represents the one way in which a functional change in the central regulation can influence the peripheral effector organ. Such a center can be conceived as undergoing a functional change as a result of inherited characteristics, a heredoconstitutional deficiency. This is in analogy with other functional constitutional deficiencies of centers in the central nervous system.

The manner in which such a functional change in the center of regulation causes an increase in the intraocular pressure can be conceived as follows. Impulses from the eye reach the center, but the ability of the cells of the center to react to such impulses is diminished to a variable degree. Fewer impulses leave the center to reach the terminal nerve endings within the eye. The result is a diminution in the production of acetylcholine in the effector organ. Such a diminution of impulses from the center may be more pronounced in the arm of the effector organ, which has to do with the maintenance of a constant volume of aqueous, namely, the ciliary body and the tissues of the angle of the anterior

chamber, with its venous system Or, the diminution of central impulses may be predominant in the choroidal vessels, which have to do with maintenance of the constant volume of blood In the first case, the constant volume of aqueous is not regulated centrally and is increased, in the second case, the constant volume of blood in the vessels of the choroid is not regulated and is increased Or, all the effector units may receive a diminished number of impulses, and both the volume of aqueous and the volume of blood in the choroidal vessels are increased, and with this increase there is a corresponding increase in the intraocular pressure

Several variations in increase in the intraocular pressure may be conceived

- 1 There may be a slow and gradual reduction in the impulses from the regulating center, especially to units of the effector organ, which maintain the volume of the aqueous The result is a slow and gradual increase in the intraocular pressure, with an increase in the volume of the aqueous

- 2 There may be a slow and gradual increase in the volume of the blood in the choroidal vessels, with a resulting gradual increase in the intraocular pressure

- 3 With the slow and gradual increase in the intraocular pressure, there may be sudden temporary extreme reductions in, or perhaps even complete cessation of, central impulses The result is a sudden or sharp rise in the intraocular pressure Such a sudden rise is especially likely to occur when there is a sudden increase in the volume of blood in the choroidal vessels

That there is an actual reduction in the production of acetylcholine in the eyes with glaucoma may be inferred from the work of Bloomfield<sup>6</sup> The aqueous of 7 eyes with chronic simple glaucoma was tested in a manner similar to that used with the aqueous of the 10 nonglaucomatous eyes previously mentioned In no instance did a sample from these eyes produce a detectable parasympathicomimetic depression of the cardiac contraction Bloomfield concluded that, in contrast to the aqueous of nonglaucomatous eyes, no acetylcholine-like substance is demonstrable in the aqueous of eyes with chronic simple glaucoma when tested by his method

#### PATHOGENESIS OF GLAUCOMA

With the theory advanced for the maintenance of normal intraocular pressure, I have attempted to explain the manner in which an increase in the intraocular pressure can be brought about Assuming the explanation to be acceptable, one may consider how the clinical forms of glaucoma fit it

## CLASSIFICATION OF GLAUCOMA

There are two fundamental types of glaucoma

1 Secondary glaucoma, in which the increase in intraocular pressure is due to organic changes which affect the units of the effector organ for the maintenance of intraocular pressure in the eye

2 Primary glaucoma, in which the increase in the intraocular pressure is purely functional in origin and is not due to any organic change in the eye. Organic changes occur in the later stages and are the consequences of the continuous increase in intraocular pressure

*Primary Glaucoma*—Although a number of syndromes have been classified under this heading, there is in reality only one disease, primary glaucoma. Either the disease manifests itself by a slow, insidious increase in the intraocular pressure, and is then spoken of as chronic simple glaucoma, or its insidious course is interrupted by a sudden increase in the intraocular pressure, an acute attack, which, because the vessels of the eye are overfilled with blood, is spoken of as acute congestive glaucoma. Such an acute attack is not a separate disease, but only an acute episode in the course of primary or chronic simple glaucoma. The acute episodes are not severe at times, and, because of the milder manifestations of the individual symptoms, they are spoken of as prodromal attacks, meaning that they frequently precede a severe acute attack.

Primary glaucoma is thus one disease and manifests itself as (1) chronic simple glaucoma and (2) acute congestive glaucoma.

How does chronic simple glaucoma fit the explanation for the production of increased intraocular pressure which I have presented?

*Chronic Simple Glaucoma*—The symptoms of chronic simple glaucoma are well known and need not be reviewed here. However, it is necessary to separate sharply the changes which are the consequences of the persistently high intraocular pressure from the symptoms which appear early in the course of the disease. In the early stages, before secondary changes have occurred, there are no visible alterations in the eye, either in the anterior segment or in the optic disk, and the eye does not differ in appearance from the normal eye. There are no subjective symptoms. At this time the eye with chronic simple glaucoma differs from the normal eye, first, in the greater lability or instability of the intraocular pressure during the twenty-four hours of the day, even when the low readings are still within the normal limits, and, second, in the gradual increase of the intraocular pressure above that for the normal eye.

The course is somewhat as follows. At about the age of 40, or shortly before, the intraocular pressure becomes more labile and shows greater variations. Tests made at this time show greater variations in response than in a normal eye. This lability or instability persists, and

within an indefinite period the intraocular pressure not only shows the greater variations but continues to be higher than that of the normal eye. Again, in an indefinite period the intraocular pressure becomes still higher, and with this persisting secondary changes begin to appear.

The absence of any organic changes in the eye in the early stages of this disease, and the whole course until secondary changes occur, leave no doubt that the disease is functional. As the transition from the normal intraocular pressure to a persistently increased pressure is a gradual one, and as the earliest indication of the disease is a greater lability of the intraocular pressure, a number of tests have been introduced which test this lability. Recently Bloomfield and Lambert<sup>7</sup> have developed a new test which seems to be an improvement over the older ones. A sphygmomanometer cuff, which has been placed loosely about the patient's neck, is inflated to a pressure of 40 to 50 mm. of mercury, while at the same time one of his hands is immersed over the wrist in ice water. With this test, which they called a lability test, Bloomfield and Lambert found that normal eyes reacted with an increase in the intraocular pressure of 1 to 9 mm. of mercury. The patients with the earliest stages of glaucoma reacted with an increase of 9 to 19 mm., and the patients with the more advanced disease, with an increase of 8 to 30 mm.

Bloomfield and Lambert also investigated the effect of drugs on the response to their lability test. One fact was brought out which is of great interest here. They found that pilocarpine in clinical dosage appreciably reduced the abnormal lability of the intraocular pressure in each of 13 eyes with chronic simple glaucoma on which operation had not been performed. I pointed out the importance of this observation in the discussion following their presentation.

Pilocarpine is a cholinergic drug and is known to act on the effector cells innervated by postganglionic cholinergic nerve fibers. The action is a direct one and occurs after nerve section and complete nerve degeneration. The drug has an effect similar to the muscarinic action of acetylcholine. The observation of Bloomfield and Lambert shows that pilocarpine administered to their patients with glaucoma acted on the cells of the effector organ for the maintenance of intraocular pressure in the same manner as does acetylcholine. The inference is clear. The effector organ is intact, for it responds to the action of pilocarpine, as it normally does to the action of acetylcholine. It can be inferred, further, that in eyes with chronic simple glaucoma acetylcholine is not produced in sufficient amounts to act continuously on the effector organ. Variations in the continuous state of the intraocular pressure can be assumed to be due to

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<sup>7</sup> Bloomfield, S., and Lambert, R. K. The Lability of Ocular Tension. A Test to Determine Individual Variations, *Arch. Ophth.* **34**: 83 (Aug.) 1945.

variations in the amount of acetylcholine produced at the nerve endings of the postganglionic fibers in the effector organ

*Primary Disturbance in Chronic Simple Glaucoma*—In the second section of the paper, I have given the reasons that a primary functional change in the postganglionic fibers or in the cells of the ciliary ganglion cannot be accepted. The only functional change which can be assumed is in the origin of the impulses in the regulating center in the brain. I come, then, to the necessary conclusion that the primary disturbance in chronic simple or primary glaucoma is a persistent functional deficiency in the central regulation for maintenance of the intraocular pressure, and that this functional deficiency is in the center in the brain from which the regulating impulses emanate.

There are no known etiologic factors but heredity which can be held responsible for such a deficiency in the central regulation for maintenance of the intraocular pressure. I have already discussed this in my previous publication.

As in my publication of 1938, I come to the following conclusion as to the nature of chronic simple or primary glaucoma.

The disease is a heredoconstitutional one, affecting the mechanism for the maintenance of normal intraocular pressure. In certain persons, as a result of an inherited defect, this mechanism is constitutionally inferior. This constitutional inferiority is already inherent in the germ plasma and is the cause of the comparatively shorter period of normal activity of the mechanism. In advancing life in most cases of glaucoma, or in early life in the rare cases of juvenile glaucoma, the mechanism loses its normal stability and is at first able to maintain normal intraocular pressure only in an incomplete manner. This is shown by the greater diurnal variations in the intraocular pressure and by the abnormal responses to tests. Gradually the inability to maintain normal intraocular pressure increases until it cannot be maintained at all. There is a functional change in the central regulation, by inference situated where the impulses for maintaining the normal intraocular pressure originate—in the center in the brain. I have said that the center of regulation is situated in or near the Edinger-Westphal nucleus. I am inclined to the assumption that the center is situated in this nucleus. Each half of such a bilateral paired center is subject to the same heredoconstitutional defects as the other half, but not necessarily to the same or to an equal degree. A bilateral paired center so situated explains certain variations in the course of primary glaucoma: (1) the difference in time of onset of the disease in the two eyes, (2) any difference in the tempo of progress of the disease in the two eyes; (3) the onset of an acute attack in the course of the disease in one eye only, or first in one eye and later in the other.

*Variations in the Clinical Picture of Chronic Simple Glaucoma*—With the theory thus elaborated, there fit in certain variations in the clinical picture of chronic simple glaucoma. Usually in this disease it is found that the lens-iris diaphragm is pushed forward, with consequent diminution in the depth of the anterior chamber. In many cases, however, the anterior chamber is of normal depth, and ophthalmologists since Raeder frequently make the distinction between glaucoma with a shallow chamber and glaucoma with a deep chamber. Such a variation may be explained as follows:

The deficiency in the center of regulation causes a reduction in the number of regulating impulses to reach the units of the effective organ which maintain, respectively, the constant volume of the aqueous and the constant volume of blood in the choroidal vessels. The units form two distinct arms of the effector organ. With the deficiency in the center of regulation, lack of sufficient impulses must be assumed to affect both arms of the effector organ. But it is also conceivable that the lack of regulating impulses affects predominantly one or the other. When the units for maintaining the constant volume of the aqueous are predominantly affected, there will be predominantly an increase in the constant volume of the aqueous. The aqueous fills the chambers equally, and the anterior chamber remains normally deep.

When the lack of regulating impulses affects predominantly the unit of the effector organ for maintaining the constant volume of blood in the choroidal vessels, an increase in the intraocular pressure is predominantly due to the increase in the constant volume of the blood in the choroidal vessels. The result is a swelling of the choroid sufficient to push the vitreous and the lens-iris diaphragm forward, and the anterior chamber becomes shallow. As cases of glaucoma with a shallow chamber predominate over those with a normal or deep chamber, I assume that in most cases the constant volume of blood in the choroidal vessels is predominantly affected. This is perhaps borne out by the labihty test of Bloomfield and Lambert. It will be recalled that this test consists of two parts: (1) immersion of the hand and wrist in ice water, causing a reflex increase in blood pressure, which drives an additional slight amount of blood into the vessels of the eye, and (2) constriction of the veins of the neck, which obstructs the outflow of blood from the vessels of the eye. The test is thus primarily a test to determine whether the eye will counteract an attempt to increase the constant volume of blood in the vessels of the choroid.

*Acute Congestive Glaucoma*—An attack of acute congestive glaucoma is accompanied with (1) severe pain in the eye and in the head, usually in the distribution of the ophthalmic branch of the fifth nerve, (2) sudden reduction in vision, (3) ciliary injection, a cloudy cornea, a shallow anterior chamber, an immobile, dilated and frequently irregular

pupil and a plasmoid aqueous, and (4) a sudden rise in the intraocular pressure, which may reach 90 mm or more. There is no doubt that all the ocular symptoms are due to the sudden increase in intraocular pressure, which causes a sudden tenseness and stretching of the corneoscleral coat and a sudden interference with the circulating blood in the vessels of the eye. It is the suddenness of the increase in the intraocular pressure that is important. This is the primary change, and it is necessary therefore, to explain this sudden increase.

It should be remembered that a sudden attack of acute congestive glaucoma is not a disease in itself, but that it is an acute episode in the course of chronic primary glaucoma. Whenever it occurs, even as the first indication of glaucoma, chronic primary glaucoma has already existed for some time. The same statement holds true for the milder prodromal attacks. The deficiency of the central regulation has already existed for some time. The assumption is therefore justified (1) that there occurs a sudden temporary reduction in, or perhaps even cessation of, the impulses from the central regulation and (2) that, as a result, it is the constant volume of blood in the vessels of the choroid that is more markedly and more quickly affected. The sudden pronounced increase in the volume of the choroidal vessel results in the sudden pronounced increase in the intraocular pressure, which is the cause of of the symptoms enumerated in the preceding paragraph.

That such a sudden reduction in the regulating impulses is not permanent is shown by the fact that an acute attack at times subsides by itself and by the fact that physostigmine at times produces a reduction of the acute attack.

#### SECONDARY GLAUCOMA

It is not necessary to review here the nature of secondary glaucoma. This is clear from the definition given earlier in the paper. In every case of secondary glaucoma there are organic changes within the eye which interfere with the functions of the units of the effector organ (1) with the outflow of aqueous through the angle of the anterior chamber and its venous system, (2) with the circulation of the aqueous from the posterior to the anterior chamber and (3) with the maintenance of the constant volume of blood in the vessels of the choroid.

I have already mentioned the glaucoma which occurs with a nevus flammeus of the face, part of the Sturge-Weber syndrome. This form of secondary glaucoma is of great importance theoretically. The course of the disease imitates that of chronic simple glaucoma. Yet it is known that the glaucoma associated with this syndrome is secondary to an angioma of the choroid, evidence of the importance of the constant volume of blood in the vessels of the choroid.



## CONCLUSION

With the understanding of the maintenance of normal intraocular pressure as outlined, the nature of primary glaucoma is conceived of as follows

1 It is a heredoconstitutional functional disease, involving primarily the function of central regulation of the intraocular pressure

2 In some persons, as a result of inherited influences, at about middle age or earlier the central regulation becomes unstable. Impulses from the center reach the effector organ in the eye in normal numbers at times and in smaller numbers at others

3 As a result, the chemical mediator acetylcholine is produced in an irregular manner at the nerve endings in the effector organ, and the action of this organ is irregular. The intraocular pressure is normal at times and high at others

4 The normal intraocular pressure is maintained by the constant volume of the aqueous in the chambers of the eye and by the constant volume of blood in the choroidal vessels. These constant volumes are maintained by the activity of the units of the effector organ in the eye

5 The effector organ for maintenance of the normal intraocular pressure consists of three units—the ciliary body and the angle of the anterior chamber with its venous system, which maintain the constant volume of aqueous, and the choroidal vessels, which maintain a constant volume of blood in the choroid

6 When insufficient impulses from the central regulation reach the units of the effector organ, either the constant volume of the aqueous is increased or the constant volume of the blood in the choroidal vessels is increased, or both are increased. The result is glaucoma with a normal anterior chamber when the increase in the volume of the aqueous predominates, or glaucoma with a shallow chamber when an increase in the constant volume of blood in the choroidal vessels predominates

7 Primary glaucoma is one disease only. It either manifests itself by an insidious onset and a slowly progressive course—chronic simple glaucoma—or the course is at times interrupted by a sudden, intense increase in the intraocular pressure, which produces severe symptoms, characterized as acute congestive glaucoma, or milder symptoms, characterized as a prodromal attack of acute glaucoma

8 Secondary glaucoma is the increase in intraocular pressure which results when the outflow of aqueous from the chambers of the eye or the constant volume of blood in the vessels of the choroid is interfered with by organic changes within the eye

# CONTACT LENSES FOR CORRECTION OF MYOPIA COMPLICATED BY LESIONS OF THE RETINA AND CHOROID

PAUL TOWER, M D  
LOS ANGELES

THE ADVANTAGE derived from the use of contact lenses for the correction of refractive defects of the eye, as well as their value in the compensation of certain pathologic conditions of the cornea, has been extensively discussed in the literature. Rugg-Gunn<sup>1</sup> described the improvement in visual acuity obtained with contact lenses in different types of ametropia, O'Rourke<sup>2</sup> and Sitchevska<sup>3</sup> reported on the optical correction of keratoconus by means of contact glasses, and Cogan<sup>4</sup> demonstrated their value in cases of bullous keratitis. But little experience seems as yet to exist concerning the indication of contact lenses for compensation of visual impairment due to myopia concomitant with degenerative processes in the fundus of the eye. As far as could be ascertained, such a use of contact lenses has been reported only by Mihalyhegyi,<sup>5</sup> who in a series of 7 cases found contact lenses to be superior to conventional spectacles in the correction of the refractive error, as well as in the resulting visual acuity.

It is obvious that contact glasses are unable to improve degenerative conditions in the fundus of the eye. However, they are effective in the correction of faulty refraction, and increase the visual perception in myopic patients to a considerable degree. This fact is especially gratifying in cases in which myopia coincides with extensive pathologic changes in the fundus.

The beneficial effect of contact lenses will be appreciated when their specific advantages are clearly understood. With spectacles, the fixed

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1 Rugg-Gunn, A. Contact Glasses for Ametropia, *Lancet* **2** 1067 (Nov 15) 1930

2 O'Rourke, D. H. Optical Correction of Conical Cornea with Contact Glasses, *Am J Ophth* **12** 187 (March) 1929

3 Sitchevska, O. Contact Glasses in Keratoconus and in Ametropia, *Am J Ophth* **15** 1028 (Nov) 1932

4 Cogan, G. Bullous Keratitis, *Arch Ophth* **25** 941 (June) 1941

5 Mihalyhegyi, G. Improvement of Visual Acuity with Contact Glasses in the Presence of Lesions of the Retina and Choroid, *Klin Monatsbl f Augenh* **108** 200 (March-April) 1942

lens and the movable eyeball are combined into a heterogenous optical system. This discrepancy, as Duke-Elder<sup>6</sup> pointed out, is apt to produce a great number of visual disturbances. The retinal image may undergo variations as to size, marginal changes in power are apt to produce distortions, oblique rays are not sharply focused on the retina but, rather, spread over a more or less diffuse area. Moreover, there

TABLE 1—*Size of Retinal Image Depending on the Use of Contact Lenses*

Diopter strength of lens	-20	-10	-6	-2	0*	+2	+6	+10
Size of retinal image	1.45	1.19	1.10	1.03	1.00	0.97	0.92	0.865

\* 0 represents ametropia, with the size of the retinal image indicated at 1

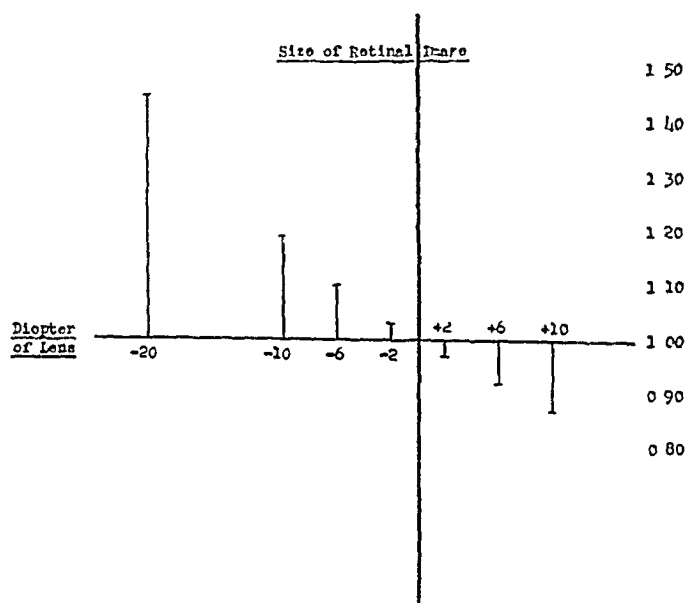


Fig 1—Size of retinal image, depending on the use of contact lenses

may occur changes in perspective, chromatic aberrations and reductions in the field of vision. Occasionally, the use of spectacles may, furthermore, produce imbalance of the ocular muscles.

When contact glasses are prescribed, many of these disturbances will disappear. As the lenses are worn on the eyeball in apposition to the cornea, the distance between the lens and the eye is reduced to a minimum. The contact lens is centered in front of the pupil and moves in coordination with the eyeball, thus eliminating distortion, increasing the field of vision and preventing aberrations. The resulting gain in visual acuity assumes great importance, especially when myopia is com-

6 Duke-Elder, S. *Practice of Refraction*, ed 3, Philadelphia, P. Blakiston's Son & Co, 1938, p 337

plicated by a pathologic condition of the fundus. Even in those cases in which through correction with conventional glasses only a slight improvement of vision can be achieved, contact lenses may lead to a noticeable increase in the accuracy of optical perception and afford the patient great relief.

The closer a concave lens can be brought to the eye, the larger is the resulting image. Thus, the greatest improvement in vision will be

TABLE 2—*Data on Twelve Cases of Myopia Concomitant with Lesions of the Fundus in Which Contact Lenses Were Fitted*

Case	Age, Yr	Pathologic Condition of Fundus	Vision with Glasses	Vision with Contact Lenses	Wearing Time, Hr
1	17	Choroiditis (congenital syphilis)	O D 5/200 O S counting of fingers at 2 ft	O D 20/40— O S 20/100	7
2	24	O D Retinochoroiditis O S Injury loss of eye	O D 20/200	O D 20/30	12
3	16	Destruction of choroidal and retinal tissues, peripapillary atrophy	O D 20/40 O S counting of fingers at 1 ft	O D 20/30 O S 20/200	8
4	35	Retinitis pigmentosa	O D 20/50 O S 20/200	O D 20/40 O S 20/70	3
5	41	Small white choroidal patch near macula with pigmentary deposits	O D 20/40— O S 20/40—	O D 20/20— O S 20/20—	5
6	31	Choroiditis with extreme thinning of retina	O D 20/60— O S 20/60—	O D 20/50 O S 20/50	8
7	27	Grayish spots in macular areas	O D 20/40— O S 20/40—	O D 20/20— O S 20/20	5
8	33	Choroiditis with heavy pigmentation and atrophic areas	O D 20/50— O S 20/50	O D 20/30 O S 20/30	7
9	32	Atrophic patches of retina and choroid with pigmentation	O D 20/70 O S 20/70	O D 20/30 O S 20/30	4
10	21	O D Diffuse choroiditis O S Normal	O D 20/70— O S 20/20—	O D 20/50 O S 20/20+	10
11	22	Small whitish yellow spots (Tay's choroiditis)	O D 20/30 O S 20/30	O D 20/20 O S 20/20	9
12	24	Choroiditis with atrophic areas around disks	O D 20/30— O S 20/40—	O D 20/20— O S 20/30	8

obtained when the lens is placed in almost physical contact with the cornea. On the basis of mathematical calculations, the increase in the size of the retinal image is approximately 20 per cent in the case of a —10 D lens. In carefully selected cases of near sightedness, therefore, patients will experience a considerable gain in visual acuity through the use of contact lenses.

In spite of all these objective advantages, the subjective element of the patient's psychology cannot be excluded. The prescription of

contact lenses will prove successful only if the patient fully realizes that in his particular case the wearing of such glasses is indispensable for obtaining adequate vision. My experience confirms the opinion of Thier<sup>7</sup> that for the patient the strong stimulus of poor vision is needed as a compelling incentive to induce him to use contact lenses, and to wear them progressively oftener and over a more extended period of time.

The present study is based on a series of 30 cases of myopia in which the patients were fitted with contact lenses. While in 18 of these cases there occurred only minor changes of the fundus, in 12 the eyeground presented evidence of a serious pathologic process. Visual acuity increased in all 30 cases, but the improvement was most pronounced in the cases with advanced degeneration of the fundus of the eye. The wearing time varied between a minimum of three hours and a maximum of twelve hours daily and amounted to an average of seven hours. There was no complaint of discomfort resulting from the use of contact lenses, but in a number of cases cloudiness and visual disturbances developed after varying periods of time, necessitating removal of the lenses. Some patients, however, were able to reinsert the lenses after thirty minutes to one hour and again obtain clear vision.

The nature and concentration of the "buffer solution" may have a certain influence on the patient's tolerance of the contact lens. But in at least 6 cases it was noted that the properties of the fluid were of no importance, and 1 patient, who wears his lenses for twelve hours every day, even uses plain water and asserts that it causes less disturbance and no irritation.

Thier<sup>7</sup> has shown in interesting experiments that whenever the contact lens does not fit too tightly the liquid is replaced by lacrimal secretion within fifteen or twenty minutes. It would seem, therefore, that the quality of the fluid used is of importance only in those cases in which the lens fits tightly over the eyeball and the lacrimal circulation cannot replace the solution quickly.

In the following section, 4 characteristic cases are described in which contact lenses led to improvement of vision in patients with degenerative conditions of the fundus of the eye, concomitant in every instance with myopia. The pathologic conditions included retinosis, choroiditis, retinitis pigmentosa and Jensen's retinitis (retinochoroiditis juxtapapillaris). In each of these cases all refracting media were clear and neither palpebral nor corneal lesions were encountered, in some instances opacities were present in the vitreous.

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<sup>7</sup> Thier, P. F. X., in Ridley, F., and Sorsby, A. *Modern Trends in Ophthalmology*, New York, Paul B. Hoeber, Inc., 1940, p. 308.

## REPORT OF FOUR CASES

CASE 1—M D, a girl aged 17, had congenital syphilis, which persisted in spite of active treatment over an extended period. The last Wassermann reaction of the blood was 3 plus.

Examination of the right eye with a  $-11.75$  D sphere revealed vision of 5/200, vision in the left eye with a  $-12.00$  D sphere permitted counting of fingers at a distance of about 2 feet (60 cm).

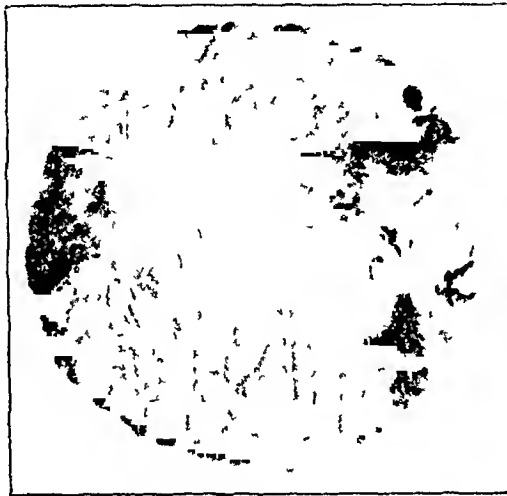


Fig 2 (case 1) —Photograph of the left fundus, showing choroiditis concomitant with retinosis and pigmentation.



Fig 3 (case 2) —Photograph of the right fundus. In the neighborhood of the macula, choroid, as well as retina, has been absorbed, a broad staphyloma separates the optic nerve from the retina.

Ophthalmoscopic studies demonstrated numerous floating opacities in the vitreous of both eyes. In the left eye choroiditis was encountered, coinciding with retinitis pigmentosa. As the retina was greatly thinned out, the choroidal landmarks had become clearly visible. Examination of the right eye led to similar findings.

Contact lenses were prescribed, and the patient is gradually becoming accustomed to their use. At present, she is able to wear them for a period of seven hours daily.

With contact glasses, vision has improved to 20/40 — in the right eye and to 20/100 in the left eye

CASE 2—G G, a man aged 24, one year previously had lost the left eye as the result of injury. The best correction for the remaining (right) eye, of  $-14.00$  sph  $\ominus -1.00$  D cyl, axis 180, gave vision of 20/200

Inspection of the fundus of the eye revealed pronounced myopic changes. In its temporal portion, the optic nerve had become separated from the retina by a broad staphyloma. In the neighborhood of the macula appeared areas in which the choroid, as well as the retina, had deteriorated and the sclera was clearly visible. Throughout the entire fundus, the retina was rarefied and thinned to such an extent that the choroidal landmarks were pronounced.

A contact lens was prescribed, and the patient is able to wear it without any discomfort throughout the day. His vision has improved to 20/30. This improvement removed the obstacle of reduced eyesight and allowed the patient to return to his former work as a mechanic.



Fig. 4 (case 3)—*A*, photograph of the right fundus, showing complete destruction of the choroid in the region of the macula and in another area just nasal to the disk, *B*, photograph of the left fundus, showing areas of degeneration of the retina and choroid.

CASE 3—R B, a youth aged 16, had vision of 20/40 in the right eye with a correction of  $-7.00$  D sph  $\ominus -2.25$  D cyl, axis 180, vision in the left eye with a  $-7.00$  D sphere permitted counting of fingers at a distance of 1 foot (30 cm).

In the right eye (fig. 4 *A*) an area of destruction of choroidal and retinal tissue and of pigmentation was present on the nasal side, starting from the optic disk. Around the papilla atrophy was clearly evident. Rarefaction of the retina had progressed to such a point that the choroidal landmarks had become visible. The region of the macula was marked by complete destruction of the choroid and was patterned with deposits of pigment. In the left eye (fig. 4 *B*) the degenerative condition of the retina, accompanied with heavy pigmentation, was clearly evident. An area of choroidal atrophy appeared below the disk in the nasal direction.

Contact lenses were prescribed, which the patient is wearing daily for a period of at least eight hours. With these glasses vision has improved to 20/30 in the right eye and to 20/200 in the left eye.

CASE 4—L K, a woman aged 35, had vision of 20/50 in the right eye with a correction of  $-0.50$  D sph  $\ominus$   $-2.75$  D cyl, axis 180, and of 20/200 in the left eye with correction of  $-0.50$  D sph  $\ominus$   $-3.00$  D cyl, axis 175. The fields were uniformly contracted. The patient had had night blindness since early childhood.

Examination of the fundus revealed retinitis pigmentosa in both eyes, the appearance of the right eye differed little from that of the left. There appeared all the characteristics of progressive pigmentary degeneration of the retina. At the periphery, patches of irregularly shaped black pigment were observed, together with atrophic discoloration of the optic nerve, and thinning of the retinal vessels to such a degree that they were barely visible.

Contact lenses were prescribed, and the patient was observed during one year. Vision was improved to 20/40 in the right eye and to 20/70 in the left eye. With these lenses she was able to see many more details, although repeated tests failed to demonstrate any extension of the limited field of vision. At first, the resulting correction was insufficient to overcome the disinclination of this nervous patient to

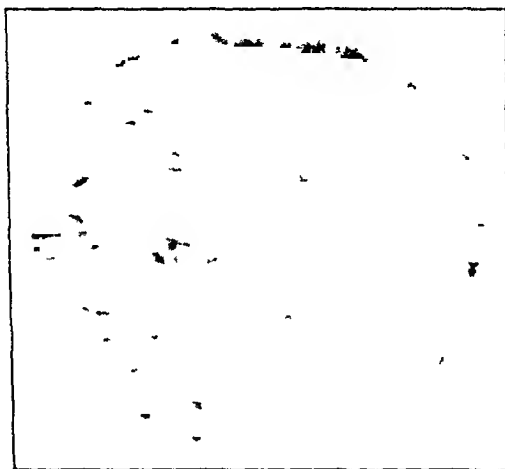


Fig 5 (case 4) —Photograph of the right fundus, showing retinitis pigmentosa

wear contact glasses for extended periods. She is, however, slowly improving in this respect, and is receiving increasingly greater benefit from her contact lenses.

#### CONCLUSIONS

Even though contact lenses cannot remedy existing pathologic changes in the fundus, their use in cases in which this condition complicates myopia has led to promising results. Improvement of vision was obtained in each case of the series reported here.

From experience in the present cases, success would seem to depend on two definite prerequisites—the one objective and the other psychologic. First, contact lenses, in order to be tolerated by the patient, must produce considerably greater correction of visual disturbances than spectacles, second, the patient must be willing to undergo a period of trial and accommodation to the new glasses. Only if these two conditions are fulfilled will the prescription of contact lenses prove to be entirely satisfactory.



## SUMMARY

Contact lenses were prescribed in 30 cases of myopia concomitant with degenerative conditions of the fundus of the eye. The data on 12 cases, presenting more pronounced pathologic changes are presented, 4 of which are described in detail.

In each case, vision was greatly improved as to clarity and detail of objects perceived.

Contact glasses were well tolerated by all patients, however, in most cases the ease with which they were tolerated was directly related to the benefit which they afforded.

The reasons for the improvement of vision through the use of contact lenses in selected cases of myopia are discussed.

In selected cases, contact lenses are superior to spectacles in the correction of deficient vision due to myopia concomitant with a pathologic condition of the fundus.

## Correspondence

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### RECENT ADVANCES IN THE PHYSIOLOGY OF VISION

*To the Editor* —In an article entitled "Recent Advances in the Physiology of Vision—Part II," published in the *British Medical Journal* (1:913-916 [June 28] 1947), the author, H. Hartridge, protests against the continued acceptance of the so-called trichromatic theory of color vision, first postulated by Thomas Young. The value of his report to the ophthalmologist, however, will probably lie in the information concerning recent researches on color vision rather than in the arguments for or against any one type of color theory. Hartridge believes that the results of more critical methods of research demand that the three receptor form of theory be abandoned in favor of some polychromatic form. Special reference is made to Granit's work, reviewed by the author in Part I of this report (*Brit M J* 1:637-639 [April 27] 1946), in which a microelectrode technic was applied to individual nerve fibers of the retina of many mammals to determine spectral response curves. Granit observed as many as seven response curves in the frog and four in the cat. The seven "modulators" observed in the frog fall into three main groups, corresponding with red, green and blue light. Hartridge believes this grouping may explain in part why vision has so long been thought to be trichromatic.

Stimulated by Granit's work, Hartridge attempted a microstimulation of the human retina by utilizing "tenuous beams of light" sufficiently narrow to subtend at the eye an angle of only 8 seconds of arc and to form on the retina, he claims, geometric images equal to one-fifth cone unit. (One "cone unit," according to Hartridge, subtends an angle at the observer's eye of 41 236 seconds of arc.) Employing a finely adjustable fixation light, the geometric image of which equaled less than one-tenth cone unit, he found that the fixation point for maximal response to different spectral rays was not the same. In all, seven different fixation points were located, namely, those for red, orange, yellow, green, blue-green, greenish blue and blue. As determined on three occasions, the mean values of these locations varied by less than one-fourth cone unit. However, a beam of white light remained white in appearance wherever it was situated on the retina. This work, as well as Granit's, suggests that there are at least seven individual receptors. To be fully understood and appreciated, the details of the retinal microstimulation technic must be read in Hartridge's longer report (*Phil Tr Roy Soc, London, s B* 232: 519-671 [May] 1947). Questions will arise in the reader's mind as to the possibility of such a minute control of fixation, especially in the light of the unsteadiness of the eye's fixation found by Adler and Flegelman (Influence of Fixation on Visual Acuity, *ARCH OPHTH* 12: 475-483 [Oct] 1934). Results are given only for Hartridge's left eye. I have not been able to find any statement that other observers were used.

Hartridge amplifies his thesis with arguments drawn from other fields of color response. In section II he discusses color mixture experiments and contends that the reduction of saturation undergone by mixed colors as compared with the matching monochromatic color and the resultant need to employ negative values to procure a perfect match suggest that color vision is polychromatic (as opposed to trichromatic). As he develops the situation, components of seven spectral colors are required to match perfectly the extreme red, the yellow, the blue-green and the extreme violet of the spectrum, taken as examples. In section III he considers briefly the various types of color blindness, all of which, he believes, cannot be explained by the partial or complete deficiency of a single sensation mediated by one of three receptors. In this connection, he does not discuss Wright's alternative suggestions for explaining these situations on a trichromatic basis (Wright, W. D. *Researches on Normal and Defective Colour Vision*, London, Henry Kimpton, 1946, pp. 352-354). Section IV deals with the inconstancy of the receptor curves determined with foveal and extrafoveal stimuli and with subjects having certain color deficiencies, and section V, with data on hue discrimination. It is unfortunate that in this section he illustrates his arguments with a hue discrimination curve for "one subject with normal colour vision," since this curve departs markedly from the careful determinations of other investigators, including the recent work of Wright and Pitt. To explain the troughs and peaks found in this hue discrimination curve, Hartridge concludes that color vision must be mediated by not less than five types of receptor. This conclusion is at variance with that of Wright (*Researches on Normal and Defective Colour Vision*, London, Henry Kimpton, 1946, p. 172) and Pitt (*Proc Roy Soc, London, s B* 132: 113-115, 1944), who find the trichromatic theory adequate to explain the shape of the hue discrimination curve. Sections VI and VII are devoted to the difficulty in explaining, on a trichromatic basis, the changes in hue undergone by colors (*a*) by reduction of visual angle, (*b*) by reduction of illumination and (*c*) by the use of peripheral vision. These changes, he believes, could be explained by assuming that foveal vision is mediated by at least four receptors—red, orange, blue-green and greenish blue—the addition of yellow and blue receptors constituting full color vision in the parafoveal region—and, in order to explain the invariable appearance of white as white, by assuming that these receptors are present in complementary pairs. The dropping out of complementary receptors in pairs would, then, account for the changes in hue observed. Since, however, the changes in hue experienced under the conditions noted by Hartridge are markedly dependent on the brightness ratio between color and its surround, the argument here is not entirely convincing. This is the case also in a later correspondence item by Hartridge (*Brit M J* 2: 69 [July 12] 1947), in which he states that if small test objects of bright red, bright green and lemon yellow are placed on a black background and viewed at a distance, the yellow is seen as pale gray or white, while the red and green retain their color. This phenomenon, he claims, argues against the trichromatic theory, which explains yellow as a mixture of red and green. Experiments of this type also, however, yield results which

depend on the brightness ratio between color and background, as well as on the chroma of the colors compared. When, for example, Munsell pigments of equal chroma and value are placed on a gray surround of the same value and viewed at a distance, the order of disappearance of red, yellow and green is by no means the order found by Hartridge.

The physiology of vision is a difficult and controversial subject. Hartridge's article is challenging and will serve to arouse controversy. This, no doubt, was part of his intention.

GERTRUDE RAND, PH D, New York

Institute of Ophthalmology, College of Physicians and Surgeons

# News and Notes

EDITED BY DR W L BENEDICT

## GENERAL NEWS

**National Study of Congenital Malformations and Maternal Infection.**—In an effort to collect more precise data on the relations between certain maternal infections and congenital malformations, a nationwide study is being sponsored by the American Academy of Pediatrics and the National Society for the Prevention of Blindness, Inc. Questionnaires are being sent to obstetricians, ophthalmologists and pediatricians, seeking the reporting of cases of rubella in expectant mothers and of children with congenital defects that might be attributed to other infections in the expectant mother, such as measles, chickenpox mumps and influenza

Although an association has been established between the occurrence of rubella early in pregnancy and certain congenital defects in the offspring, information is lacking as to the frequency with which this happens and as to the possible influence of other communicable diseases that might have been contracted by the expectant mother

Data will be studied by the following committee Herbert C Miller, M D, Kansas City, Kan, Stewart Clifford, M D, and Clement A Smith, M D, both of Boston, Josef Warkany, M D, of Cincinnati, James Wilson, M D, of Ann Arbor, Mich, and Herman Yannet, M D, of Southbury, Conn Physicians knowing of cases are urged to register them with Dr Miller, chairman of the committee

## SOCIETY NEWS

**Ohio State Optometric Association**—On Wednesday afternoon and evening, November 5, the Dayton Safety Council of the Chamber of Commerce and zone 9, Ohio State Optometric Association, are cosponsoring a familiarization "Seminar on Industrial and Occupational Vision," to be held at the Van Cleve Hotel, Dayton, Ohio All members of the ophthalmologic professions are cordially invited to attend The seminar will start at 2 30 p m, with the program as follows

- 2 30 p m Introduction Occupational Vision, Dr F E Billette, president, zone 9, Dr R N Roth, seminar chairman
- 3 00 p m Proneness to Accidents and the Employee's Vision, N C Kephant, Ph D, La Fayette, Ind
- 3 30 p m Industry and Seeing—One Aspect of Occupational Seeing, Joseph H Tiffin, Ph D, La Fayette, Ind
- 4 00 p m The Nurse in the Industrial Vision Program, Mrs Hazel H Leedke, R N, Kaukauna, Wis
- 4 30 p m A Testing and Training Program Utilizing Visual Classification, Correction and Placement of Employees, Mr Dave Ekberg, Dayton, Ohio

5 00 p m Aspects of a Plant Safety Goggle Program, Mr Bill Carroll, Columbus, Ohio

7 00 p m Dinner, to be followed by round table discussion and question and answer period

The registration fee is \$5 per person, including cost of dinner Reservations may be made with Dr R N Roth, 2324 Salem Avenue, Dayton, Ohio

**German Ophthalmological Society of Heidelberg**—The German Ophthalmological Society of Heidelberg is making preparations for resuming its meetings in Heidelberg in 1948, the last meeting having taken place in Dresden in 1940

The society has published in the past seven years the following three books von Tschermak-Seysenegg, A Einführung in die physiologische Optik, 1942, Velhagen, K · Sehorgan und innere Sekretion, 1943, and Lauber, H Das Gesichtsfeld, 1944.

Further information can be obtained from Dr E Engelking, Universitäts-Augenklinik, Heidelberg, Germany

# Abstracts from Current Literature

EDITED BY DR WILLIAM ZENTMAYER

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## General Diseases

THE SYNDROME KNOWN AS "REITER'S DISEASE" (A TRIAD OF POLY-  
ARTHRITIS, URETHRITIS, AND CONJUNCTIVITIS) W P U JACK-  
SON, Brit M J 2: 197 (Aug 10) 1946

The patient is usually a young adult with an irregular fever and one or more of the three symptoms indicated. The conjunctivitis is bilateral and catarrhal or profusely purulent, with episcleritis and sometimes iritis or keratitis. No organism can be noted in conjunctival smears. The arthritis affects the large joints, with pain, and is often flitting. Synovitis is frequent, the fluid may be purulent but is always sterile. The urethral discharge is abundant and purulent, without any organism, and is sterile on culture. The disease sometimes begins with diarrhea and a generalized rash. Complement fixation tests for gonorrhea and Wassermann tests give negative reactions. The disease is self limited, though subject to recurrence. This syndrome is important, as it resembles a gonococcal infection, but with the latter there is a history of contact and of urethritis which precedes the other symptoms. The gonococcus is present except in the conjunctival discharge. The fixation test usually gives a positive reaction, and the responses to treatment in the two conditions are different. No treatment seems to be of particular avail for Reiter's disease except to put the patients to bed for six weeks to three months. Three cases are reported.

ARNOLD KNAPP

## Glaucoma

PERSONALITY PATTERNS OF WHITE ADULTS WITH PRIMARY GLAUCOMA  
H L HIBBELER, Am J Ophth 30 181 (Feb ) 1947

Hibbeler, in a preliminary survey of patients with primary glaucoma, found that males tended to depression and hysteria and females to paranoia and schizophrenia.

W S REESE

GONIOTOMY FOR CONGENITAL GLAUCOMA URGENT NEED FOR EARLY  
DIAGNOSIS AND OPERATION O BARKAN, J A M A 133. 526  
(Feb 22) 1947

Barkan makes a plea for the early recognition of congenital glaucoma, since if goniotomy is performed soon after discovery of the condition the symptoms can be relieved and the pressure in most cases permanently normalized, with resulting useful vision and normal appearance. Of 76 eyes with infantile glaucoma on which goniotomy was performed, pressure was normalized in 66, with vision maintained or restored over periods of from one to ten years. In 10 eyes the operation was unsuccessful. Glaucomatous atrophy of the optic nerve was the exception in this series. It occurred only in the few cases in which normalization of pressure was unduly delayed. In 1 case the excavation

of the nerve head almost disappeared after normalization of pressure. The abstracter has reported the occurrence of this unusual sequel to sclerocorneal trephining in a case of chronic simple glaucoma.

J A M A (W ZENTMAYER)

### Injuries

A CASE OF A SPLINTER OF GLASS IN THE ANTERIOR CHAMBER OF FOUR YEARS' DURATION W B DOHERTY, *Am J Ophth* 30: 177 (Feb.) 1947

Doherty reports a case in which a splinter of glass in the angle of the anterior chamber apparently disappeared after operation. He remarks the difficulty encountered in such cases and suggests the use of reflexless instruments. He has had several of these made.

W. S. REESE.

### Lens

EXTRACTION OF DISLOCATED LENSES BY THE HIGH FREQUENCY NEEDLE OF JESS AND LACARRÈRE A GARDILČIĆ, *Ophthalmologica* 112: 255 (Oct-Nov) 1946

Jess recommended extraction of lenses which are dislocated into the vitreous by means of a high frequency electric needle. The present report is a modification of Jess's method. A conjunctival flap is thrown down, and before the section is made a high frequency needle is inserted through the limbus into the interior of the eye. It is then pushed into the lens and the current is switched on. This is done under control with an ophthalmoscope or with transillumination. The needle becomes adherent to the lens by virtue of coagulation of the lens protein. After coagulation occurs, the incision is made for the extraction and the lens or cataract carefully removed. Corneoscleral sutures, which were placed at the beginning of the operation, are then tied, and the conjunctival flap is sutured in place. One case is reported.

F H ADLER

1

### Methods of Examination

OBJECTIVE TESTING OF RETINAL FUNCTION BY THE ELECTRORETINOGRAM IN A CASE OF CONCENTRIC CONTRACTION OF THE VISUAL FIELD M MONNIER and M AMSLER, *Ophthalmologica* 110: 225 (Nov-Dec) 1945

Electroretinograms have been obtained on human beings by a number of investigators. Monnier and Amsler describe their technic, which they applied in a clinical case, that of a woman aged 52, who had had an accident without direct injury to the skull, and who showed as a result of this trauma concentric narrowing of the visual fields, diminution of central visual acuity, insufficiency of convergence, fatigability during reading and muscae volitantes.

The visual fields changed on various occasions, but never measured more than 60 degrees temporally and 35 degrees nasally. Both pupils



reacted to light, and adaptation of the retina was normal. The electroretinogram for this patient, taken from the peripheral portions of the retina, which were apparently blind, showed normal excitability, so that the authors believe that the impulses were normally discharged from the retina into the optic nerve. They conclude that these discharges did not reach the visual centers but were stopped at either the lateral geniculate bodies or the level of the synapses in the occipital cortex.

F H ADLER

### Neurology

PSYCHOLOGICAL REACTIONS IN WAR-BLINDED W M HARROWES,  
Brit M J 2 129 (July 27) 1946

This is a brief review of the cases of 40 war-blinded men who, while undergoing training for reconstitutive processes, such as Braille reading, typing, shorthand, woodwork and basketmaking, were studied in an attempt to discover the indications presented by each man for types of future occupation. In addition, psychiatric examinations were carried out along the lines of Adolf Meyer's personality study. Three late reactions to loss of vision were noted: (a) tension, (b) overcompensation and (c) restabilization.

ARNOLD KNAPP

AMBLYOPIA CUM POLYNEUROPATHIA CAUSED BY STARVATION A W  
MULOCK HOUWER, *Ophthalmologica* 112.177 (Oct-Nov) 1946

The author, who was formerly the head of the department of ophthalmology at the University of Batavia, Netherlands East Indies, was interned by the Japanese from March 1942 until September 1945. During his internment in the various prison camps, he had an opportunity to observe a number of patients who exhibited a syndrome which he calls "camp eye." The patients complained of difficulty in reading and of inability to recognize persons at a rather short distance. Examination showed a reduction of central visual acuity and, in every case, a central or paracentral scotoma.

In the early cases the scotoma was relative, in the very serious cases it was absolute. The fundi were normal save for slight changes in the macular area, which consisted of absence of the foveolar reflex, even in patients under 40 years of age, a slight granular appearance of the foveola and drusen of Bruch's membrane. The patients had nearly all experienced abnormal sensations in the feet, legs, hands or forearms for some time. These sensations consisted of a prickly feeling or of an abnormal sensation of heat or cold. A few patients had nutritional edema. In some patients hemorrhages were present in the inner layers of the retina. In some of the more advanced cases, pallor of the temporal part of the optic disk developed. The author believes that the condition in these cases of "camp eye" is analogous to the toxic amblyopias and the amblyopia in serious cases of hyperemesis gravidarum.

He considers that the chief cause of the disease is a lack of vitamin thiamine. A deficiency in other vitamins of the B complex and a

generally poor diet, consisting mostly of carbohydrates, are favorable to the development of the syndrome. The patients with recent onset of the disease recovered under treatment with large doses of thiamine hydrochloride. The author advises the administration not only of thiamine hydrochloride but also of the other vitamins of the B complex, especially nicotinic acid. The diet should be poor in carbohydrates, as the disproportion between the high intake of carbohydrates and the deficiency of vitamin B may play an essential part in causing the central scotoma. Sodium nitrite may be given for vasodilatation to speed up recovery.

F H ADLER

### Ocular Muscles

PATHOGENESIS AND TREATMENT OF CONCOMITANT STRABISMUS A DEL BARRIO, Arch Soc oftal hispano-am 6: 863 (Sept) 1946

The author expresses the belief that strabismus is caused by the absence or insufficiency of the retinal convergence reflex, which is developed in the first years of life. At that age there is great power of accommodation, which produces an excess of convergence, but if the retinal convergence reflex is strong enough it can maintain the normal position of the eye and binocular vision. However, if the reflex is weak, binocular vision is lost and convergent strabismus appears.

In cases of divergent strabismus there is an insufficient retinal convergence reflex, which manifests itself after the age of 8 or 10 years, being compensated for before that time by the excessive accommodative power, which acts on convergence. Only when accommodation begins to weaken after that age is binocular vision lost and the eye which is in divergence seeks the position of rest. Errors of refraction act as an accessory factor, as well as everything which diminishes vision or in any way alters the physiologic sensorial or motor relations.

Optical treatment rarely modifies the degree of squint, it may, however, improve vision when associated with temporary occlusion of the fixing eye. After the age of 12 years the treatment of squint should be surgical and functional.

Surgical treatment must produce an overcorrection of 10 or 15 degrees in patients with convergent squint up to 20 years of age and of 5 degrees after that. With divergent squint a slight convergent position should be the endeavor.

Functional treatment is indicated only in cases in which the vision of the amblyopic eye is above 1/10. At the beginning the orthoptic training should be given without any instrument, a light and a colored glass are sufficient. The author gives in detail his method of functional treatment and claims that in a few days, with patients of fair intelligence, binocular vision is gained. Later, exercises with the stereoscope and the diploscope are given, and, finally, Javal's exercises for controlled vision are performed. The average duration of the course of functional treatments is one or two weeks, daily sessions of a half-hour being given in the office and the patient repeating the exercises at home.

H F CARRASQUILLO

## Operations

ARTIFICIAL THICKENING OF THE CONJUNCTIVAL FLAP IN FISTULIZING OPERATIONS A P FILHO and S R SEBAS, Brasil med 59. 1 and 7 April 1945

The relative frequency of intraocular infection following fistulizing operations is mentioned. Sections of sheep eye showed thinning of the conjunctival covering of the fistula. To increase the thickness of the flap, the submucous tissue is utilized by bringing it over the fistula.

M E ALVARO

## Orbit, Eyeball and Accessory Sinuses

PULSATING TRAUMATIC ENOPHTHALMOS REPORT OF A CASE S KALFA, Vestnik Oftal 25 41, 1946

A patient aged 24 had been injured four years previously in the left orbit. Anophthalmos and ptosis followed the injury. An unsuccessful attempt was made in another hospital to correct the ptosis. There was a defect in the upper outer wall of the orbit. The eye presented enophthalmia (5 mm with Hertel's exophthalmometer), marked esotropia, limitation of movements outward, ptosis and pulsation of the eyeball, visible through the eyelids. No bruit was elicited. A tenotomy of the left medial rectus muscle straightened the eyeball. After this tenotomies were performed of the other rectus muscles, but the enophthalmos remained unchanged.

Kalfa believes that the enophthalmos in this case was due to dislocation of the fragments of the upper orbital wall with displacement of the orbital fat into the skull. The pulsation of the eyeball was caused by the defect in the upper orbital wall, through which the pulsation of the brain was transmitted to the eyeball. The absence of bruit and of dilated veins in the eyeball confirms this view. This condition could be considered as spurious exophthalmos.

O SITCHEVSKA

## Parasites

SUBCONJUNCTIVAL CYSTICEROSIS G BURSUK, Vestnik oftal 25:40, 1946

A woman aged 33 showed on examination a round, firm swelling at the upper temporal region of the right eyeball under the conjunctiva, which seemed to be attached to the palpebral part of the lacrimal gland. The eyeball was normal otherwise, vision was 10. All tests, including a roentgenographic examination, gave normal results except for an increase of eosinophils in the blood (9 per cent). The patient was scheduled for operation, but on that day she presented a semitransparent, milky white vesicle, which came out of the eyeball. On examination the head of the worm was found, thus the cysticercus perforated the conjunctiva. Cysticercosis of the eyeball is rare. In Russia 117 cases of this condition were recorded in sixty-five years. In Leningrad only 1 case was found among 70,000 patients with ocular disease. This case is reported because of the unusual manner of self expulsion through the conjunctiva.

O SITCHEVSKA

## Pharmacology

SIGNIFICANCE OF ACTION OF PAREDRIE ON THE OCULAR TENSION OF RABBITS E SCHMERL, *Am J Ophth* 30:187 (Feb) 1947

Schmerl found that paredrine hydriobromide aqueous (a 1 per cent solution of *p*-hydroxy- $\alpha$ -methylphenylethylamine hydrobromide in distilled water, made tear isotonic with 2 per cent boric acid and preserved with merthiolate, 1:50,000) applied locally to the pericorneal vessels of rabbits caused increased intraocular tension, dependent on the vascular bed and the quantity of pericorneal vessels constricted

W S REESE

## The Pupil

MIOSIS CONGENITA J C HOEST, *Acta ophth* 20:293, 1942

The author discusses the previous reports of Hoeth and Berner on miosis congenita. One of Hoeth's patients was reexamined after an interval of twenty years. The pupils remained very small and were without reaction. The patient had poor vision, day blindness and spasm of accommodation, which was helped by the regular use of atropine.

In a case of Redslob's, with histologic study, the musculature of the iris showed defective development. In another case of the author's there was absence of the dilator muscle and an atypical ciliary muscle, much of the muscle being found in the periphery of the iris.

O P PERKINS

## Physiology

PERMEABILITY OF THE BLOOD-AQUEOUS BARRIER OF THE NORMAL EYE TO FLUORESCENIN WALTER HAEFELI, *Ophthalmologica* 112:226 (Oct-Nov) 1946

A method was devised by Amsler and Huber (*Ophthalmologica* 111:156, 1946) by means of which the amount of fluorescein could be estimated in the anterior chamber of the intact eye. These authors found, contrary to the previous opinion of investigators, that fluorescein, even in the normal eye, appeared in the anterior chamber in measurable quantities. Although the amount varies somewhat from one subject to another, the normal limits have been well established, which Haefeli speaks of as "the normal band."

The present paper deals with the further determination of this normal band. Two cubic centimeters of a 10 per cent solution of fluorescein sodium is injected into the antecubital vein. The time of the injection is recorded, and the time of the appearance of the fluorescein in the anterior chamber is determined with a slit lamp beam and observation through the binocular microscope. By introduction of a resistance, the intensity of the light is reduced to the point at which no green coloration can be seen in the aqueous. A direct proportionality exists between the concentration of fluorescein in the anterior chamber and the strength of current, in amperes, of the light

source at which the fluorescein just becomes visible. Curves are constructed in which the abscissas represent the time and the ordinates the values, in amperes. Two hundred graphs of the normal band are given. The author finds that fluorescein passes into the aqueous humor approximately four minutes after intravenous injection. In children under 15 years the fluorescein appears more quickly. In general, the maximum concentration of fluorescein is reached in twenty-five to thirty minutes. In any one subject, the two eyes show the same permeability. Fluorescein remains in the anterior chamber for several hours, considerably longer than in the blood stream. The permeability determined at different times varies only slightly for the same person. When injected in smaller quantities than usual, fluorescein passes more slowly into the aqueous but attains almost the same concentration. The fluorescein enters the anterior chamber free of albumin.

F H ADLER

### Refraction and Accommodation

MYOPIA DUE TO A SULFONAMIDE DRUG. REPORT OF A CASE, WITH EXPLANATION OF ITS PATHOGENESIS. O VON FIEANDT, *Acta Ophth* 20 24, 1942

A careful study was made of a case in which myopia developed after ingestion of a sulfonamide drug. By atropinizing one eye only, determining the refraction and the accommodative power of the two eyes and observing the subsequent behavior after instillation of atropine and physostigmine, the author reaches the conclusion that the myopia is the result in part of a spasm of the ciliary muscle and in part of changes in the lens of the eye.

O P PERKINS

### Retina and Optic Nerve

THE PERIOPTIC ATROPHIC RING AND ITS RELATIONSHIPS. R PICKARD, *Brit J Ophth* 30: 437 (Aug) 1946

The cause of the atrophic rings which are occasionally observed around the optic disk was studied in 826 consecutive patients over 50 years of age. The eyes were classified according to the presence or absence of atrophic rings and the normality or narrowing of the retinal vessels. If the narrowing of the vessels was present in any part, that eye was classified as having narrow vessels. The only lesions common to cavernous atrophy, glaucoma and atheroma were the narrowed vessels and the rings. The theory is proposed that the rings and the cavernous atrophy are the consequence of a change in the circle of Zinn, analogous to that which occurs in the retinal vessels. On the other hand, the changes in glaucoma are due to pressure and consequent narrowing of the vessels or pressure on the nerves as they pass around the cup. If the cavernous atrophy is due to vascular trouble, operation will do no good and this was true in a few cases in which it was tried.

W ZENTMAYER

THROMBOSIS OF THE RETINAL VEIN TREATED WITH HEPARIN REPORT  
OF 30 CASES ROSENGREN AND SFENSTROM, Acta ophth 20:145,  
1942

In 30 cases thrombosis of the retinal vein was treated with injections of heparin daily for an average period of ten days. In 10 cases the thrombosis was in the trunk and in 20 cases, in branches of the vein. Improvement was obtained in 21 cases, the condition became worse in 5 cases and remained unchanged in 4 cases. The thromboses of the trunk were comparatively little influenced. The average improvement in visual acuity was from 0.239 to 0.375. This slight improvement was less evident two to four weeks after cessation of the treatment.

O. P. PERKINS

### Trachoma

THE TREATMENT OF TRACHOMA E. O. MARKS, Brit. J. Ophth 30:  
213 (April) 1946

For the past twenty-five years Marks has had the care of trachomatous children at the Hospital for Sick Children and at the Wilson School Ophthalmic Hostel, at Brisbane, Australia. The children came from the dry inland areas of Western Queensland, where trachoma is prevalent. The differential diagnosis was rendered somewhat difficult because in those areas the dryness of the atmosphere, the dust and the glare combine to form irritating conditions for the conjunctiva, with consequent common irritative conjunctivitis. In running tests in which the two, seemingly equally affected, eyes were treated by different local methods, it did not appear to matter what one applied locally, other than lavage to keep the eyes clean, with perhaps the exception of the sulfonamide drugs. These substances, when administered orally, were of great value in treating secondary infections but did not benefit the trachoma. They seemed less efficient in local application.

W. ZENTMAYER

TREATMENT OF TRACHOMA WITH STREPTOCIDE [SULFANILAMIDE]  
A. VOLOKITENKO, Vestnik oftal 23:32, 1944

The mechanism of the action of sulfonamide drugs in treatment of trachoma can be explained by the activation of the reticuloendothelial system. Experimental work confirmed this view, as Volokitenko obtained the growth of young fibroblasts on sections of the third lid in rabbits after injecting into them a diluted cytotoxic-antireticulo-endothelium serum.

Thirty patients with various stages of trachoma were treated with gradually decreasing doses of sulfanilamide. In the majority of patients the blood picture showed a decrease of leukocytes and of hemoglobin. The author concludes:

1. Complete cure was obtained in 60% per cent of patients with trachoma who were treated with sulfanilamide.
2. The daily dose of sulfanilamide should not exceed 1.0 to 1.5 Gm.
3. In some cases complete cure was obtained in only two to three months.
4. Vision was improved in all but 4 patients.
5. The local application of sulfanilamide drops had no bearing on the therapeutic results, so that the drug was

given only internally 6 The best results were obtained in the granulation stage of trachoma Flattening of the granules was observed on the eighth day and their absorption in two to three weeks The pannus began to disappear about the fifteenth day

O SITCHEVSKA

### Tumors

MELANOMAS OF THE CHOROID C d'AQUILA DE CASTAÑE DECOUD,  
An argent de oftal 5.123 (Oct-Dec) 1944

Seventeen cases of melanoma occurring in patients operated on during a period of ten years at the department of ophthalmology of the Faculty of Medicine of Rosario are described pathologically by the chief of the laboratory A classification is made on the basis of cellular elements and the pigment content

The following summary is given 1 Of a total of 33,694 cases, there were 17 cases of melanoma of the choroid, a proportion of 0.05 per cent Of these tumors, 15 were pigmented and 2 were achromic Of tumors composed of cells of the same type, those with pigment were notoriously more malignant 2 The range of ages was from 40 to 80, the tumor being more frequent between the ages of 40 and 60 3 In 7 cases the tumor was located at the equator of the eyeball, in 6, in the anterior segment, in 2, in the posterior segment, and in 2 cases the position was not mentioned 4 The patients were followed up to the time of the report, the number of years varying from two to ten 5 The tumor is usually round and circumscribed and surrounded by melanophores of the choroid, which form a membrane, the tumor herniating through this membrane in some cases 6 According to the type of predominant cell, the tumors were classified as follows round cell, 8 cases, fusiform cell, 6 cases, mixed cell, 2 cases, and unclassified, 1 case Extraocular extension of the tumor was noted in 4 cases The article is illustrated with photomicrographs

H F CARRASQUILLO

### Uvea

MENOPAUSAL IRIDOCYCLITIS M E REDSLOB, Ann d'ocul 178:225  
(June) 1945

The etiology of iridocyclitis is discussed In about 25 per cent of cases the etiologic factor cannot be determined Within the past few years some progress has been made With improvement in diagnostic facilities, various etiologic agents have been uncovered The author is particularly interested in the susceptibility of women to iridocyclitis, especially during the menopause The physiology of the estrogens is discussed When the normal endocrine balance is disturbed, as in the menopause, the female is more prone to infections There is some similarity to diabetes, which is an endocrine disturbance It is well accepted that diabetic persons are more susceptible to infections than nondiabetic persons A truly diabetic iritis is rarely seen, though iritis due to other causes is frequently seen with diabetes

The author mentions the work of Dejean, who expressed the belief that in the majority of cases iridocyclitis is due to tuberculosis This

conclusion is based on response to therapy rather than on clinical proof Redslob, however, feels that the iritis occurring during the menopause is probably of syphilitic origin. The syphilis may be masked but, nevertheless, is probably the cause.

Two cases of iridocyclitis in women aged 49 and 50, respectively, are reported. Both patients were having menopausal symptoms. The first had congenital syphilis and the only therapy that helped the second was neoarsphenamine.

P. R. McDONALD

THROMBOPHLEBITIS AS A FOURTH SYMPTOM OF RECURRENT IRITIS  
WITH HYPOPYON. B. ADAMANTIADES, *Ann. d'ocul.* 179:143  
(March) 1946

Ophthalmologists and dermatologists have for some time been interested in the syndrome of recurrent iritis and hypopyon. Previous to this report the cases reported have had in common iritis, aphthous ulcers of the mouth and genital ulcers. The author has recently seen 2 cases in which retinal hemorrhages of the type associated with thrombophlebitis were present. In reviewing the previously published cases, he found that this lesion had been frequently noted but no particular attention had been paid to it.

The author reports 2 cases that presented the lesions characteristic of this syndrome. The etiologic basis of the condition has never been settled. Some consider it to be tuberculous, others, a staphylococcal infection. Because of the periodicity of the iritis, it is felt that the disturbance must have an allergic basis.

The disease resembles periodic ophthalmia of horses and may be caused by a filtrable virus or by brucellosis.

P. R. McDONALD

PULMONARY CHANGES IN CHRONIC AND ACUTE IRIDOCYCLITIS, SCLEROKERATITIS AND CHOROIDITIS. L. ESSEN-MOLLER, *Acta ophth.* 20:97, 1942

This article deals statistically with roentgenologic findings in a control group of 442 cases and in 186 cases of chronic iridocyclitis, 140 cases of acute iridocyclitis, 62 cases of sclerokeratitis and 44 cases of choroiditis.

In cases of chronic iridocyclitis, active changes in the hilus were found oftener than in the control group. Active, or even healed, changes in the lungs proper were not definitely more frequent. Nor were any changes noted more frequently in the cases of acute iridocyclitis. The cases of sclerokeratitis showed an increased incidence of healed pulmonary lesions. The choroiditis group did not show an increased incidence of any type of pulmonary lesion.

O. P. PERKINS

PROGNOSIS OF CHRONIC IRIDOCYCLITIS. L. ESSEN-MOLLER, *Acta ophth.* 20:121, 1942

The author made a statistical survey of 244 cases of chronic iridocyclitis treated at the eye clinic of Lund University between 1928 and 1939. In 1938, reexamination in 211 of these cases showed healing in 70 per cent and active iridocyclitis in 30 per cent. The tendency to



healing was greater in cases of unilateral than of bilateral involvement and was perhaps a little better in males than in females. However, in only 45 per cent of cases did the eyes heal without residual complications which reduced vision, in 42 per cent visual acuity was less than 0.3, in 30 per cent the patient became practically blind, and a diminished earning capacity of 80 per cent to 100 per cent was the result in 20 per cent.

The visual acuity and the person's earning capacity tended to become less the longer the period of observation.

Increased intraocular tension was observed in one third of the cases. If this was slight and transitory, it did not affect the prognosis, but if it were high or prolonged, the prognosis was less good, particularly if operative intervention was necessary.

O. P. PERKINS

### VISION

PSYCHOLOGICAL REACTIONS IN SOLDIERS TO THE LOSS OF VISION OF ONE EYE, AND THEIR TREATMENT. P. M. DUKE-ELDER and E. WITTKOWER, *Brit M J* 1:155 (Feb 2) 1946

The authors begin with the statement that the loss of one eye is not in itself a severe disability, at the same time, persons who have lost an eye are often unduly distressed about their defect and feel handicapped in numerous activities out of proportion to their actual disablement. Their handicaps are not anatomic in origin but are due to what is commonly described as a functional overlay. The war has developed conditions in which study of the reactions of persons who have lost one eye is made possible, these conditions are important, as the same reactions are met in civilian life.

A series of 102 patients were examined. The disability in 39 was due to disease and in 63 to injury. Twenty-six of these men were seen within six months of the onset of the disease or the occurrence of the injury, 15 had chronic ocular disease, 61 had been blind in one eye as the result of disease or of injury for at least six months.

The emotional reaction to monocular injury and disease is then described. The emotional reaction to permanent blindness in one eye was studied. In 47 of 61 men there were evidences of morbid fears concerning their social relationship, the future economic security of their dependents and the possibility of further harm to themselves. These reactions were classified as follows: social anxiety, 26 men, anxiety over dependents, 10 men, self-centered and self-pitying anxiety, 11 men.

The factors which determine the emotional reactions are (1) previous personality, (2) nature of the disability and (3) nature of employment.

The authors conclude that the psychologic effect of the loss of an eye is out of proportion to the actual physical disability. Of this group, 78 per cent showed abnormal psychologic reactions. The fear of blindness is so general that the loss of one eye causes undue anxiety as to the remaining eye. This leads to certain symptoms referable to the good eye, such as eyeache, eyestrain, photophobia and night blindness. These functional symptoms, rather than the actual defect,

are responsible for the impairment in efficiency of the one-eyed man. Adequate treatment of these patients is not completed with the medical attention to the eye. The psychologic treatment should be begun and carried on not only in the hospital but also in convalescence. During the latter period Duke-Elder and Davenport (*Brit J Phys & M Indust Hyg*, 5:88, 1942) stated that "rapid restoration of physical fitness, training to compensate for the loss of binocular vision and to readjust the faculty of orientation, and measures to overcome the psychological distress of mutilation are essential."

Finally, attention is drawn to the importance of improving the occupational prospects of the one-eyed worker by means of impressing on the public and on private employers the negligible loss of efficiency in most vocations in the case of the one-eyed worker.

This is a very well written and important article, which merits careful reading and consideration.

ARNOLD KNAPP

### Therapeutics

PENICILLIN IN CAVERNOUS SINUS THROMBOSIS A. G. VASIUTINSKY,  
*J Ophth* 1:25, 1946

An officer of the Soviet army, aged 24, had severe thrombosis of the right and left cavernous sinuses, the cause being a furuncle of the nose. There was rigidity of the neck and hemiparesis. Vision was limited to light perception in each eye.

Penicillin was injected (15,000 units every four hours) for a period of four days. The temperature was normal in eight days, the exophthalmos of the left eye disappeared in fourteen days, and vision was 0.4 in the right and 0.5 in the left eye, a month later vision was normal in the left eye. Slight exophthalmos and ptosis remained in the right eye. A corneal ulcer which developed in the right eye also disappeared during this period. Vasiutinsky states that this is the first instance of cure in a case of thrombosis of the cavernous sinus which he has observed among his 25 patients.

O. SITCHEVSKA

PENICILLIN THERAPY IN OPHTHALMOLOGY M. KRASNOV, *Vestnik oftal* 25:9, 1946

Krasnov analyzes the bacterial and chemical action of penicillin and the methods of its application. American penicillin was used with good results in an army hospital in cases of exudative uveitis, iridocyclitis and endogenous iritis. Intramuscular injections only were used daily, the total dose during a course of treatment ranging from 100,000 or 200,000 units to 2,000,000 units. A patient with syphilitic iritis responded well to treatment with 1,000,000 units of penicillin administered within ten days. Vision was improved from 0.02 to 1.0. Herpetic keratitis did not respond to treatment. A patient with severe intrabulbar neuritis of the optic nerve exhibited spectacular improvement in vision, from finger counting to 0.9, within a few days. Sulfonamide drugs used previously had had no effect. In a case of bilateral syphilitic neuritis penicillin therapy produced no improvement and the Wassermann reaction of the blood remained positive. Subconjunctival

injections of penicillin were accompanied with pain after the injections Krasnov states that more clinical experience is necessary in order to evaluate the effect of penicillin therapy

O SITCHEVSKA

INTRAOCCULAR INJECTIONS OF PENICILLIN J A VAN HEUVEN, Nederl tijdschr v geneesk 90 1006 (Aug 17) 1946

Van Heuven used 2 cc of a solution of penicillin sodium (10,000 units of penicillin per cubic centimeter) for the irrigation of the anterior chamber of the eye. One of the patients, aged 74, had undergone an operation for cataract, which was followed by infection and panophthalmia. The second patient, aged 19, had been hit in the eye with a tennis ball. In the second patient an ulcer had developed at the margin of the cornea and sclera with hypopyon. In both patients irrigation with the solution of penicillin was followed by disappearance of the hypopyon. In the second patient the irrigation of the anterior chamber was repeated in five days. This procedure was followed by great improvement.

J A M A (W ZENTMAYER)

# Society Transactions

EDITED BY DR W L BENEDICT

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NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

Brittain F Payne, M D, *Chairman*

Milton L Berliner, M D, *Secretary*

*Jan 20, 1947*

## INSTRUCTION HOUR

**Effects of the Atomic Bomb on the Human Eye.** COLONEL J E ASH,  
Director, Army Institute of Pathology, Washington, D C

Information is to be cleared through the Surgeon General's Office  
at a later date

## REPORT OF CASES

**Rheumatoid Involvement of the Extraocular Muscles.** DR J B  
LISMAN •

A case of recurrent diplopia is reported The condition was observed  
in a white girl from the ages of 9 to 16 years

The diplopia was due to paresis of individual extraocular muscles  
Between attacks the diplopia was always overcome by fusion A total  
of seven major episodes occurred between 1940 and 1947 During an  
acute attack, one could map out double vision due to paresis of an  
individual muscle, with diplopia increasing in the field of action of the  
muscle There was pain on looking into the field of the paretic muscle,  
with tenderness on palpation over the muscle There was repeated  
association of ocular involvement with migratory polyarthritis, erythema  
nodosum, fever, rapid sedimentation time and subcutaneous nodules  
Biopsy of a specimen of an excised subcutaneous nodule from the  
scalp revealed nonspecific fibrosis There were no cardiac abnor-  
malities It appears that the external ocular muscles were affected by  
a transitory inflammatory process, the cause of which was the same  
as that producing the generalized rheumatoid syndrome

## DISCUSSION

DR HAROLD WHALEY BROWN I saw this patient last July, just  
after the acute phase of her last attack of polyarthritis had subsided  
Her only ocular abnormality at that time was vertical diplopia when  
looking to the left The diagnosis of paresis of the right superior oblique  
muscle was made from the observation of right hypertropia with the  
greatest deviation (12 prism diopters) with the eyes down and to the  
left This deviation was apparently not due to any pain or mechanical  
interference of the action of the right superior oblique, as there was  
no discomfort or demonstrable limitation of action of the muscle in  
extreme depression of the right eye in the nasal field

Six months later (Jan 3, 1947) measurement of the muscle  
balance with the screen cover test in the six cardinal fields of gaze

revealed a balance for near vision. There was no spontaneous diplopia in any field, either with or without the red glass.

In my experience paresis of an individual muscle is an uncommon finding in cases of rheumatic fever or chronic arthritis. In cases of episcleritis there is usually no muscular paresis unless Tenon's capsule is involved. (The edema and pain on movement of the globe are the evident cause of the underaction of the ocular muscles, and usually more than one muscle is involved.) It is difficult for me to account for the attacks of transient paresis of an individual muscle of a few weeks' duration on the basis of actual inflammation of the muscle, its sheath or its tendon. I think the transient paresis can be better explained on the basis of a toxic myositis, resulting from the general systemic condition of the patient.

I should like to ask Dr. Lisman whether repeated determinations of the sedimentation rate were made and, if so, what the findings were. Also, was there always an area of tenderness or swelling over the attachment of the muscle preceding each attack of paresis of an individual muscle?

Dr. J. B. LISMAN: The sedimentation rate was high during many episodes. As to palpation over the affected muscle, I did not try it in the earlier years, since the diagnosis was rather obscure. In the past few years pain has been a constant symptom. The pain is not diffuse but seems to be localized over the affected muscle.

#### Surgical Exposure of the Inferior Oblique Muscle DR. WALTER F. JOHNSON

I am suggesting a new and direct surgical approach to the insertion of the inferior oblique muscle, which eliminates the dangers of seeking the muscle by making blind sweeps with a muscle hook and permits operation at the insertion to be carried out more easily.

This paper will be published in full in a future issue of the ARCHIVES.

#### DISCUSSION

Dr. RAYMOND EMORY MEEK: How and where to open the conjunctiva is important. On two occasions I have seen students casually pick up the conjunctiva to make the conjunctival incision in an operation on one of the rectus muscles, and then sweep a hook back and find there was no muscle there, simply because they had picked up the muscle with the conjunctiva and severed it from its insertion. After the incision is made in the conjunctiva, Tenon's capsule must be picked up and opened. Dr. Johnson uses a suture in the corneoscleral margin to pull the eye toward the nose and another suture looped around the inferior oblique to isolate the muscle. Greater adduction can usually be accomplished by using a squint hook under the external rectus muscle. Speaking of the conjunctiva reminds me of the time Dr. Wheeler came to the anatomy laboratory when I had a class at New York University. He showed us how to pick up the conjunctiva. He said the Lester forceps were to be used as a probe, passing one blade under the tissue and then pressing down the other blade, the tissue is then carefully picked up without getting too much conjunctiva.

Dr Johnson's approach has been used on both the lateral rectus and the inferior oblique muscle. In making a recession of 3 to 4 mm, we make the conjunctival incision at the inferior border of the external rectus muscle, but in making a longer recession it is usually best to make the conjunctival incision 1 mm below the lower border of the external rectus muscle. The insertion of the inferior oblique muscle is 1 to 3 mm above the lower border of the external rectus muscle.

#### PAPER OF THE EVENING

### Complications in Operations for Retinal Detachment. DR J A VAN HEUVEN, Utrecht, Netherlands

There is no reason to dwell on the operative treatment of detachment, as this subject has been extensively considered by Weve in "Modern Trends in Ophthalmology". At this time I wish merely to emphasize some of his statements. In the examination, my colleagues and I prefer to employ indirect ophthalmoscopy, with an extra strong light source. We always make a drawing of the whole fundus. The strong source of light is at the same time used for localization of the retinal tear on the outer wall of the eyeball. An assistant watches the spot where the light strikes the sclera. [Other methods of localization were discussed.] A drawing of the fundus not only assists in making sure that no part of the retina is overlooked, but makes it possible to recognize different types of detachment.

There is a possibility that accommodation plays a role in the origin of a detachment. There can be little doubt about a forward movement of both choroid and retina in accommodation, owing to the contraction of the radial fibers of the ciliary muscle. Clinical observations indicate that in special circumstances this movement may promote tearing of the retina. After operation one may see hemorrhages, both from retinal and from choroidal vessels, the prognosis of which is often not bad.

The picture of detachment of the choroid, with its sausage shape and chocolate hue, is not rare. Prognosis is good. Stellate figures and strands in the vitreous form a serious complication. These strands may appear in cases of detachment with a hole in the retina which has already been treated surgically, in cases before the operation, in cases without a hole and, last, in cases even without detachment.

The general condition of the patient seems to play a dominating role [The various therapies were discussed from this point of view.]

Tumors of the choroid can make the diagnosis difficult if they are accompanied with a large detachment. [The differential diagnosis of cysts was discussed, and, finally, detachment following inflammation, especially that of a tuberculous nature, was considered.]

#### DISCUSSION

DR ALGERNON B REESE. I understood Dr van Heuven to say that the operation is not over until the retina is back in place. The matter was then dropped, but I should like to have him carry the thought a little further, if he will. I should like to ask him how he takes care of detachments in aphakic eyes, in which it is difficult to see the periphery of the fundus. I am humbled by what Dr van Heuven has said about his operative results because of my experience with

scleral resection In 10 cases in which I did the operation I have not had a "cure" It depends, of course, on what one means by a "cure," and I feel that a cure is obtained only when the retina is back in place and vision is improved This does not mean that the vision has to be normal What do you consider a cure, Dr van Heuven?

DR FRANK A VESLY I should like to ask Dr van Heuven whether he considers the reason for detachment of the retina purely mechanical and whether he thinks that as soon as holes develop anywhere in the retina detachment is due to ensue If he holds the latter belief, how does he explain the fact that a traumatic hole of the retina in itself practically never causes detachment in an otherwise normal eye? How does he explain the failure of detachment of the retina to develop in senile eyes with large macular holes? Almost daily one sees a case of rupture of the retina without perforating wound of the sclera in which detachment does not occur As an example of the effect of a perforating wound, I should like to cite a case I saw in the Army During bayonet exercise a young soldier sustained a wound 3 mm in length about 12 mm from the limbus The wound was properly closed, and he recovered without infection Afterward, the scar in the retina was clearly visible, and detachment never occurred I also shall take the liberty to ask Dr van Heuven whether he studies the peripheral region of the fundus in senile eyes as carefully as he does in eyes with retinal detachment, and whether in such eyes he has ever seen severe cystic degeneration with multiple holes at the periphery without detachment

DR HENRY MINSKY I was much impressed with the speaker's emphasis on the role of accommodation in the production of a hole in the retina<sup>1</sup> I believe he is on the right track, for in no other way can one explain the tear except through a pull by the ciliary muscle During the last four or five years I have included, in addition to the regular diathermy, cyclodiathermy of that sector of the ciliary body in the region of the tear, and I believe the results have been a little better than before

DR J A VAN HEUVEN In answer to Dr Reese's question I said that we do not consider the operation finished before the retina is back in place That should be the aim—I do not say that we always accomplish this objective There is always a certain number of cases in which we are doubtful about the result from the beginning I think the prognosis is much better if the retina can actually be reattached at the moment of operation, we then feel more or less safe However, even though we succeed in getting the retina attached, it will not necessarily remain in position permanently, but at least it has a better start

The cases of aphakia still present a difficult problem, especially for the examination We now and then examine the aphakic eye ophthalmoscopically with use of a contact glass, which makes it easier to see the periphery of the fundus

It was also asked what I mean when I say a case is "healed" That is a good question, because there are statistics published in Europe which may be too optimistic I do not mean that these statistics are unreliable, rather, I am saying that frequently an eye has been considered "healed" when the retina was reattached, without taking into

account the function The patient, of course, is interested in what he sees, he does not mind much whether his retina is attached or not if he is blind In these statistics there are a considerable number of eyes called "healed," meaning anatomically healed, but the patients are blind This has given rise to international statistical confusion

There are cases in which a hole in the retina is not followed by detachment, at least by full detachment, of the retina I noted that foveal holes often give rise to a limited detachment It is quite true that in elderly people one may find cysts, often taken for holes, or scars of local choroidoretinitis in the periphery which are not followed by full detachment We have always thought this natural, because scar formation and healing have followed, similar to that which we try to achieve with diathermy or other therapeutic methods One sees cases in which the new rim of the retina has been firmly attached to the wall of the eye In other words, healing can occur spontaneously After traumatic puncture of the eye one occasionally sees the same thing, but as a rule we find that after a traumatic lesion of the back of the eye a detachment occurs When, for example, a piece of iron is extracted by means of a magnet, we have made it a rule to apply surface coagulation at the place of perforation and at the place where it has been extracted, if an opening in the sclera must be made

I am much interested in the relation of accommodation and detachment of the retina I omitted part of my paper on this aspect of the problem I have seen cases of high grade myopia in which after strong use of the accommodation a tear developed in the retina Our attention was drawn to this possibility because we observed it in 2 or 3 patients However, it is still difficult to say whether the detachment occurred because of extraordinary use of their accommodation

DR ALGERNON B REESE If the retina is not back at the time the operation is completed, do you carry out further drainage of the subretinal fluid, or inject air or fluid into the vitreous cavity?

DR J A VAN HEUVEN I do not inject air or fluid, but try to suck out as much of the subretinal fluid as possible, and I place the patient in a position with the area operated on as low as possible

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Brittain F Payne, M D, *Chairman*

Milton L Berliner, M D, *Secretary*

Feb 17, 1947

#### INSTRUCTION HOUR

**Local Anesthesia in Ophthalmology.** DR WALTER S ATKINSON,  
Watertown, N Y

The importance of producing complete anesthesia as painlessly as possible before beginning the operation was emphasized

Pentobarbital or phenobarbital and acetylsalicylic acid are the sedatives preferred Comparison of several local anesthetics for topical use showed tetracaine hydrochloride to be preferable Procaine hydrochloride is still considered the safest and best for injection

Of the various methods of producing temporary paralysis of the orbicularis muscle, O'Brien's is considered the most efficient The



addition of 25 per cent alcohol for operations on the globe when there is a facial "tic" with spasmodic contractions of the orbicularis prolongs the paresis to from seven to ten days

Retrobulbar injection of a solution of procaine hydrochloride within the muscle cone for operations on the globe, particularly cataract extractions, produces complete anesthesia of the globe, hypotony, a deeper anterior chamber and paresis of the rectus muscles. In cases of acute glaucoma the pain is relieved immediately, the intraocular pressure is lowered and the miotics are more effective

For dacryocystorhinostomy, block of the infratrochlear and infra-orbital nerves in the canals or in the sphenomaxillary fissure and a nasal pack produce good anesthesia

With instillation anesthesia, infiltration or lid block, complete anesthesia of the lids may be obtained

#### REPORT OF CASES

#### Cranial Epidermoid (Cholesteatoma) with Erosion of the Orbital Roof DR ISADORE GIVNER and DR HENRY WIGDERSON (by invitation)

Primary cranial epidermoids originating in the diploe of the flat bones of the skull cause expansion of the overlying bone, with typical roentgenographic findings. Cushing observed that of 2,004 tumors of the brain only 0.06 per cent were epidermoids. Of 188 cranial epidermoids reported to date, 33 were of the diploic type, to which the one reported here belongs

M. N., a man aged 84, first presented himself on Oct. 22, 1946, complaining of inability to open his left eye, due to pressure of a mass in the left frontal region, which, although present all his life, had grown considerably in the past three years. The mass was the size of a small apple, fluctuated and transmitted the intracranial pulsation. On deep palpation around the edge of the mass, the edge of the bone could be felt, suggesting absence of the frontal bone. On raising the left upper lid with the finger, one noted no elevating action of the eyeball. An immature cataract was present, the eye was otherwise normal

On Dec. 4, 1946, with local anesthesia, the cyst was removed, a portion of the capsule adherent to the dura was left. The cyst contained 75 cc of yellowish, oily, fluidlike content. The bony defect (7 cm in diameter) included not only the frontal bone but the roof of the orbit as well

When the patient looked up, the fascial roof of the orbit was retracted. When the patient looked down, the fascial roof moved upward into the cranial cavity

The postoperative course was uneventful. Examination on February 4, 1947 showed equal palpebral fissures and return of function of the elevator muscles of the left eye

#### DISCUSSION

DR HENRY WIGDERSON. It is interesting to point out the typical roentgenologic appearance of the epidermoid. This is really pathognomonic, and when one has seen it there is never any doubt about the

diagnosis again. In most instances the epidermoid is benign. I have read of 1 case of epidermoid of about sixty years' duration in which the patient had been operated on a number of times during a period of thirty to forty years. Autopsy revealed carcinoma. The present case is the only one I know of in which the epidermoid appears to have undergone a malignant degeneration. In this case it would have been fairly easy to remove all the cyst wall, but, on account of the patient's age, I did not want to attempt to do this, and perhaps tear the dura. Often it is difficult to remove all the cyst wall because the tumor is of long standing and grows into the foramina and fissures of the skull. I had a case in which the tumor not only involved all the roof of the orbit but grew down into the middle fossa and involved the carotid artery. I did not try to touch the capsule at the base, and within a year and a half the patient had a recurrence of the tumor.

DR ALFRED KESTENBAUM. Dr Givner and Dr Wigderson reported an interesting phenomenon. In their case the orbital roof was replaced by a movable membrane. This membrane showed a definite upward movement when the eye looked downward and a downward movement when the eye looked upward. In order to understand this phenomenon, I studied the physiologic movements of the lids associated with the movements of the eyes. The position of the eyelid was observed by means of a pencil, its tip being placed on the lid. Normally when the eye looks upward, the lower lid bulges forward to a certain degree and the upper lid recedes, when the eye looks downward, the lower lid recedes and the upper lid bulges forward. Let us call the plane touching the upper and the lower lid at the middle of the lid margins the "tangential lid plane." This tangential lid plane is in a vertical position in gaze straight ahead, in looking upward the tangential plane is inclined backward, in gaze downward the tangential plane is inclined forward. Hence, the tangential lid plane consistently stands more or less parallel to the basis of the cornea. In the case of Givner and Wigderson these physiologic movements of the lids occurring with the ocular movements were observed in the normal eye, whereas they were definitely diminished on the side of operation.

The mechanism of the described comovements of the lids is apparently due to two factors. First, Tenon's capsule, which moves with the eyeball, is intimately connected with the neighboring orbital tissue and indirectly with the eyelid. In gaze upward, for example, retraction of the upper part of Tenon's capsule will result in retraction of the upper lid. The connection between eyeball and eyelid is still strengthened by so-called inhibitory ligaments and by smooth muscle fibers. Therefore each movement of the cornea upward or downward will be accompanied with retraction of the upper or the lower lid. Second, as long as the orbital wall is intact, retraction of the lower part of the orbital tissue in gaze downward will, owing to a kind of unchangeable hydrostatic pressure, cause a bulging forward of the upper part of the orbital tissue and hence of the upper lid, inversely, retraction of the upper part of the tissue in gaze upward will result in bulging forward of the lower lid. The second factor, however, will be effective only as long as the orbital wall is intact. If, as in the case

reported, a movable membrane is substituted for the orbital roof, this membrane will be able to yield instead of the upper lid. In gaze downward the membrane will therefore bulge upward, in gaze upward the membrane will be pulled down into the orbit. This explanation agrees with the mentioned fact that the comovements of the lid were normal on the unaffected side but were diminished on the diseased side.

Later, I observed another case in which a part of one orbital roof had been removed surgically. Again, examination revealed that the described physiologic accompanying movements of the lids were normal on the healthy side, whereas they were definitely diminished on the side of operation. Disturbance of the physiologic accompanying movements of the lids seems, therefore, to be of significance in cases of defect of the orbital wall. However, more cases will have to be studied before this sign can be considered infallible.

DR JOSEPH IGRSHEIMER. As far as I know, only 1 case of epidermoid of the skull involving the eye has been reported in the ophthalmologic literature. As such cases are so rare, I wish to mention a case which I have been watching for several years. A colleague, aged 47, came to my office in February 1942, with the complaint that his right eye had been protruding for several days and that he could not see as well with this eye as with the other one. He said that for thirty years he had felt that something was wrong in the right frontal bone temporally and above the orbit. Within the last few weeks he had noticed growth and progressive protrusion of what he had always considered an exostosis in this region. In addition to exophthalmos and a certain diminution of vision, he noted edema of the right upper lid. This edema disappeared in a few days. There was a slight papilledema. The roentgenogram showed the characteristic Cushing sign (decalcification in the temporal part of the frontal bone). The diagnosis of cholesteatoma (epidermoid) originating in the diploe was made. He was operated on a month later, and the diagnosis was confirmed. The tumor was restricted to the anterior fossa. The bone of the orbital roof was extensively eroded. He recovered fully after the operation, except that the exophthalmos did not entirely disappear. There was recurrence a year later, demonstrated by an increase in exophthalmos, headaches and edema of the lid. The surgeon (Dr Gilbert Horrax) decided to wait and see whether the symptoms disappeared, and they did. Several years later the patient again had sensitivity in the region of the tumor and the feeling of increasing exophthalmos, but these symptoms also diminished shortly. The fluctuating character of the symptoms in this case is of interest, in this connection, I should like to mention that even before operation he showed a relative bitemporal hemianopsia, which disappeared before the operation was performed.

#### Unilateral Exophthalmos Due to Meningioma of the Middle Fossa DR HAROLD KIRSHNER (by invitation)

The causes of unilateral exophthalmos may be divided into five groups: vascular, inflammatory, tumor, trauma and general disease. These include a diversity of pathologic conditions, among which arterio-venous aneurysm, varicosities of the orbital veins, cavernous angioma,

periostitis of the orbit, thrombosis of the cavernous sinus, trauma, xanthomatosis, purpura, hemophilia and orbital tumor are most frequently encountered

A case of unilateral exophthalmos of the right eye due to pterional meningioma *en plaque* was presented. The space-occupying character of the tumor and the resulting hyperostosis of the sphenoidal ridge, the greater and lesser wings of the sphenoid, the roof of the orbit and the pterional region explain the mechanism of the exophthalmos, which measured 3 mm. The exophthalmos was not reducible. Except for diminished corneal sensitivity, no other involvement of the third, fourth, fifth or sixth cranial nerve was noted. In view of the patient's age (53) and vascular status, neurosurgical operation was deferred.

#### DISCUSSION

DR JAMES W. SMITH. I should like to review at this time a case similar to Dr. Kirshner's which I presented before this Section eight years ago. Dr. Kirshner has already referred to the classic features of the syndrome enumerated in my paper. My patient, a woman aged 53 with more extensive involvement than in Dr. Kirshner's case, was operated on by Dr. Leo M. Davidoff on Feb. 6, 1939. The slow growth of this type of meningioma was demonstrated in my case. I have had an opportunity to examine the patient repeatedly since Dr. Davidoff's operation. Since one eighth of the bony hyperostosis could not be removed with safety, a recurrence was expected. For three and a half years ophthalmic examinations revealed nothing significant. The exophthalmos has progressed about 1 mm. a year in the past four years. Vision is now reduced from 20/20 to 20/30 +. The field of vision and the fundus are normal. The patient's only complaint is epiphora, when outdoors, which is controlled by a moist chamber spectacle. I suggested a plastic device for the lid to narrow the palpebral fissure, but the patient prefers to wait until another neurosurgical procedure is indicated, which she feels will again reduce the exophthalmos. Dr. Davidoff, however, feels that, in view of the extremely slow advance of the recurrence, the patient, who is 62, should not be subjected to another formidable operation until definite pressure on the optic nerve is evident.

DR. TOMAS R. YANES, Habana, Cuba. It may be interesting to cite a case my colleagues and I had in Cuba about six months ago, that of a woman aged 40 who had exophthalmos due to a meningioma of the middle fossa. She decided to come to the States and to be operated on in Dandy's clinic. Dr. Dandy was very ill and died two or three days after her arrival, so the operation was done by an assistant, whose name I do not know. The surgeon told the family that the chances of death at operation would be about 8 per cent and that if she were not operated on she might live five, six or eight years longer. Considering her age, she decided to be operated on, and she is now perfectly well.

DR. HAROLD KIRSHNER. The only unusual feature of this case is the fact that the changes in the optic nerve appeared late, i. e., in the fifth or sixth year. In the classic syndrome of meningioma *en plaque* there are no changes in the optic nerve, at least not in the early phases of the disease.

## PAPER OF THE EVENING

## Beta Radium in Treatment of Corneal Lesions DR A D RUEDEMANN, Detroit

*Growths on the Lid*—Large, infiltrating growths suggestive of carcinoma should be excised and treated with gamma rays of radium or with roentgen rays. When the growth is small, shallow or difficult to excise, beta rays of radium are the therapeutic choice. Although beta rays are soft, only one-half a given surface dose is absorbed in 2 mm of tissue, and all minor lesions are easily and successfully treated. Small marginal growths, to which it is difficult to apply gamma or roentgen rays, can be given one or two applications, and they will be destroyed with little, if any, loss of lashes. Beta radiation can be used as well for small angiomas in babies. The time of application is short, and, with a simple holding technic, no anesthetic is required. In treatment of other cutaneous lesions around the eye, use of beta radiation is suggested, as it leaves no discoloration of the skin or depigmentation and there is no tendency to a deep bronzing effect.

*Vernal Catarrh*—If the polyps are large and long standing and fibrotic, excision is indicated. Gamma radiation is then used. The eye must be carefully screened with lead plates, the lid everted and the applicator directly applied. This therapy gives prompt relief but may need to be repeated. Cold compresses and irrigation minimize edema and reaction. Large polyps having been excised or reduced in size, beta radiation can be directly applied to the individual polyps, especially those along the superior aspect of the tarsus. Mild catarrhal lesions may be treated with spray radiation. The effect is prompt and lasting. Individual polyps and small areas are easily reached. Except in urgent cases, in which use of gamma radiation is advisable, beta radiation is preferable for children, as it can be more easily and more quickly applied. The end results are similar. A long applicator to evert the lower lid and a double length tongue blade are safety aids in therapy.

*Conjunctival Lesions*—Small lesions on the bulbar conjunctiva can be treated directly with beta radiation. Small, superficial growths require but one application, rarely two, with direct contact. Vascular growths are more resistant but can be treated with direct contact. Spray radiation is of value. Enlargement of the caruncle, enlarged pingueculae and beginning pterygium are well treated by direct application. Small pseudopterygia are treated by direct application. Large, true pterygia and pseudopterygia are treated by a combination of spray radiation over the corneal portion and direct application along the limbal portion. Recurring pterygia having interstitial vascular trunks require contact radiation over most of the extent to eliminate deep vascularization. Marginal carcinoma is satisfactorily treated with direct radiation contact.

*Cornea*—Deep and superficial keratitis, due to tuberculosis, syphilis or undulant fever, are known to be successfully treated with radiation. Other treatment should be directed at the etiologic factor. Corneal nebulae following ulcer, trauma or allergy are usually cleared, with little residual scarring. Maculas of the cornea can be substantially reduced in area and may be sufficiently cleared to enable the patient to carry on without corneal transplantation. Vascularized leukoma can be treated

so that hazard of vascularization to a corneal transplant is lessened. Corneal transplants with a tendency to vascularization can be treated to prevent complete vascularization. Diminution in the area of corneal scarring and reduction in density are major factors in beta radiation therapy.

*Treatment with Beta Radiation*—1 Treatment is either with direct contact or with spray radiation. 2 The time of treatment varies according to the type of lesion, strength of tube and reaction to treatment. 3 The time factor is important in irradiation of corneal lesions—it is difficult for children and some adults to hold still longer than twenty-five seconds. Use of a stronger tube with a short time factor is advisable. 4 Age is not a factor, beta radiation treatment has been given patients 6 months of age. 5 The only discomfort to the patient is his own fear. 6 As a measure of economy a number of patients should be arranged for treatment at one time. This cuts the cost per patient and saves time. 7 Separate record cards are kept for instant reference.

*Summary*—There is a twofold hazard in the use of radiation therapy: the danger to the patient—which lies in an overdose, in faulty application and in a severe reaction, and that to the ophthalmologist. The value of radiation therapy should be stressed because of its usefulness in so many conditions previously supposed to be incurable. The use of roentgen ray or gamma or beta radiation offers a valuable adjunct to therapeutics in ophthalmology.

To date, no definite evidence of injury to the eyes from beta radiation has been found. In several cases of severe corneal leukoma excessive treatment with beta radiation produced small perforating ulcers and enucleation was necessary. Roentgen and gamma radiation therapy may produce cataract and injure the retina permanently. It is possible to use the various forms of radiation in a single case. Care must be taken to allow for cessation of reaction if such a procedure is indicated. Photographs and drawings are valuable aids as progress notes.

#### DISCUSSION

DR HAYES MARTIN: Dr Ruedemann's presentation has been interesting to me, because it is my belief that if radiation therapy is to be used for any given disease or in any given part of the body it should be applied by specialists in that disease or in that part of the body rather than by therapeutic radiologists, who purport to treat all diseases anywhere about the body with radiation. It is encouraging that ophthalmologists themselves, such as Dr Ruedemann, are beginning to apply radiation therapy for diseases of the eye, because out of their experiences, successes, failures and disappointments (for I am sure they are going to have many disappointments and complications which they do not as yet expect) will come some real knowledge of the possibilities of radiation therapy in these diseases.

Not being an ophthalmologist, I do not know enough about the disease conditions which Dr Ruedemann demonstrated in slides to offer any worth while comment. I do not know whether these diseases could possibly have been better treated by methods other than irradiation, but I think that a final decision as to the indication for treatment of these diseases by irradiation rather than by other methods must depend on the natural course of the disease. That is to say, can Dr Ruedemann

be certain that his short term results justify the hazard of the late sequelae of irradiation?

In this connection, I think it well to keep in mind that effects of radiation are always destructive. Radiation therapy is not a tonic, nor does it have wholesome effects anywhere about the body. It is always destructive in its action on normal tissues. Even though the effects of radiation are undesirable, they are in many cases preferable to the disease for which the radiation is given. The clearest example of this is cancer, the significance of which is almost always more serious than the complications of radiation therapy.

It is well to keep in mind that the late effects of radiation never disappear, they always become worse as time goes on. The untoward effects of radiation are more serious five years after application than after one year, they are worse after fifteen years than they are after ten years, and sometimes the most serious sequelae of therapeutic radiation do not become evident for thirty or forty years—in most cases long after the radiation therapist is dead and gone.

When one goes back twenty-five or thirty years in the history of radiation therapy, especially back to the early twenties, one will find that almost every disease afflicting human beings has at one time or another been treated with radiation and glowing results have been reported. In general, few such ideas persist today. With many diseases in which there may have been a favorable response to radiation at first, it has been found on mature consideration that older, simpler methods, when revived, were superior. In other, self-limited, diseases, it was found that the clinical course was not actually influenced at all by radiation and that remission or recovery took place just as quickly without treatment. In still other diseases for which radiation has been enthusiastically advised, the sequelae have been disastrous, and sometimes fatal.

From Dr. Ruedemann's presentation, I get the impression that he believes the response to radiation is practically always favorable and that he has had few, if any, failures and no untoward sequelae. I cannot understand how there could be no complications or sequelae.

For lack of time, I cannot comment on many of the complications following radiation therapy—take as an example one of the most common ophthalmic sequelae, radiation cataract. I gathered from Dr. Ruedemann's paper that no radiation cataract had developed in his cases. Over the past twenty-five years at Memorial Hospital my colleagues and I have seen a large number of radiation cataracts, and they seem to follow small, as well as large, doses. We know of no way to prevent them except to let no radiation whatever hit the lens, in this connection it seems strange that Dr. Ruedemann made no mention of protective shielding. But, after all, so far as radiation cataract is concerned (and other complications of irradiation), the risk is justifiable provided that the disease for which the radiation is given is in itself more serious than radiation cataract (or other sequelae). In my opinion, radiation is not otherwise justified.

I listened carefully during Dr. Ruedemann's presentation for some statement regarding dosage, and I was disappointed that he made no mention of it. To say that the patient had so many applications of "beta radiation" is not enough, I should like to ask Dr. Ruedemann,

in closing, to tell us something of the dose used. The radon applicator which he mentions was devised about thirty years ago. I well remember its use at Memorial Hospital over twenty-five years ago, so there is nothing new about this phase of the subject. The dose of such a radon applicator is usually stated in millicurie minutes, I should like to know Dr. Ruedemann's dose in millicurie minutes for the various lesions he describes.

I trust that you will not consider my discussion too critical and destructive, for I do not mean it in that way, but I think it is well to utter a word of caution, since it seems to me that Dr. Ruedemann's attitude toward the problem is a little too optimistic. Radiation is not like penicillin, with which there is no after-effect whatever. It is not even like many toxic drugs of which the untoward after-effects are short lived and from which recovery can be complete. The untoward after-effects of radiation are permanent, they always persist and continue to grow worse.

In closing, I wish to repeat what I said in the beginning, that ophthalmologists themselves should continue to administer radiation wherever indicated for lesions about the eye. The ophthalmologist not only should apply the radiation himself, but should also decide on the dose. He should take on himself complete responsibility for the results, reporting untoward sequelae, and failures as well as successes. He cannot ethically transfer to a physicist or a radiologist all the technical phases of the treatment. Only by the application of such principles will progress be made in radiation therapy.

DR RAMÓN CASTROVIEJO. We are grateful to Dr. Ruedemann for his presentation on the treatment of corneal lesions with beta radiation. He seems to be somewhat discouraged with the results he has been able to obtain with keratoplasty and points out that surgeons who carry out corneal transplantation will have many disappointments. He is right in this statement. The man who undertakes to perform corneal transplantation sooner or later finds that there is no other surgical procedure in ophthalmology which gives so many complications. These complications often depend not on the ability of the surgeon to perform the operation but, rather, on the reaction of the patient's eye to the surgical trauma. There are transplants which, after a few weeks of transparency, become cloudy on account of such complications as uveitis or vascularization of the graft.

Keratoplasty is not indicated in all cases of corneal opacities and is contraindicated in many cases of corneal deformities, for there are eyes which do not lend themselves well to this type of operation. This is the negative aspect of keratoplasty. On the other hand, if the conditions have been carefully selected, such as central leukoma, interstitial keratitis and keratoconus, the well trained surgeon may expect a transparent graft in as high as 80 per cent of cases and great improvement in vision.

- In Dr. Ruedemann's treatment of corneal lesions with beta radiation, he seems to have obtained the best results in cases in which infiltration rather than fibrosis was present in the cornea. I am afraid that where there is fibrosis beta radiation therapy will not be satisfactory. In cases of densely vascularized leukoma, use of beta or roentgen radiation properly administered will be a good method of



treatment after operation, provided the irradiation is done shortly after the surgical procedure has been carried out. If the irradiation is instituted immediately after surgical treatment, the capillaries, which are responsible for recurrence of corneal vascularization, can be easily obliterated, while they are extremely radiosensitive, with a minimum dose of beta or roentgen radiation. On the other hand, if too long a time is permitted to elapse after operation before the application of radiation, higher doses of beta or roentgen radiation will be necessary to obliterate the vascularization and diminish the fibrosis, with possible subsequent damage to the eye. Dr. Martin has already pointed out not only the immediate but also the late complications in tissues which have been exposed to high doses of radium or roentgen rays.

I have not had any experience with beta radiation but have treated a substantial number of cases with roentgen rays. In the future I intend to use both beta and roentgen radiation in eyes with similar lesions in order to evaluate their respective efficacy. At present my colleagues and I do not regard as adequate the dose of roentgen radiation which we have been using after surgical measures on the cornea. We are still comparing results of treatment with different doses in order to arrive at the minimal optimum dose. The 600 r which was the standard dose used in many cases after keratectomy and keratoplasty with a tendency to vascularization was found to be insufficient. In some cases we are now giving as much as 1,200 and 1,500 r. I should like to single out for discussion some of the cases presented by Dr. Ruedemann, but limitation of time will not permit me to do so. Dr. Ruedemann has been on the pessimistic side in appraising the results of corneal transplantation in treatment of corneal lesions, on the other hand, I feel that he has been somewhat too optimistic in evaluating the results of beta radiation in treatment of these lesions. Further study of both keratoplasty and irradiation will determine more accurately the indications for each method in the treatment of corneal lesions.

DR VITO LA ROCCA. I should like to ask whether Dr. Ruedemann has used beta radiations with lesions of vernal catarrh and whether there has been any recurrence of vegetations through the scar.

DR A. TORRES-ESTRADA, Mexico, D. F., Mexico (translated literally by Dr. Ramon Castroviejo). In Mexico, my colleagues and I have been using gamma radiation for some time in the treatment of various corneal lesions. It is most often used after dacryocystorhinostomy, one of the most frequent causes of failure of which is the formation of keloids. We can prevent the recurrence of epiphora by the application of beta radiation seven days after the operation, particularly if lacrimation begins to appear. We also use roentgen radiation in the treatment of some cutaneous growths, particularly on the borders of the eyelids. Follicular conjunctivitis is best treated by two or three applications of beta radiation, which cicatrize without leaving any sequelae. In Mexico we have a great deal of vernal conjunctivitis, which is well treated with beta radiation.

Pterygium is treated in Mexico by special surgical procedures, the corneal apex of the pterygium being dissected from the cornea and Bowman's membrane preserved. The fibrous tissue of the body of the pterygium is dissected between the sclera and the epithelial layer. This fibrous tissue is excised, and the exposed area of the sclera is covered

with a conjunctival flap The area of operation is treated with gamma or beta radiation With this treatment we have few recurrences of pterygium, when they do recur, they are caused by faulty technic, faulty section of the pterygium or too extensive resection of corneal tissue

Radiation is also employed in cases of keratitis and of keratoplasty when the transplant becomes nebulous, with keratitis particularly, the application of beta radiation seems to give good results

Finally, of late we have been treating patients with advanced glaucoma with radiation, particularly secondary glaucoma due to intraocular hemorrhage Eyes which should have been enucleated have been treated with radiation, with relief of the painful symptoms, and some eyes have thus been saved from enucleation Because of this good result in treatment of glaucoma, we have used radiation in cases of hemorrhagic retinitis, with some resulting improvement I cannot give much information on the technic or dosage of roentgen irradiation Although the treatment has been given under my supervision, the technical details have been left entirely to an expert

DR A D RUEDEMANN, Detroit I wish to thank Dr Martin for his courteous discussion I am a rank amateur in the treatment of ocular lesions with radiation I can assure him I do not move without a roentgenologist, a technical man, beside me, for where the roentgenologists fear to treat should not be a fool's paradise for the rest of us. I can assure you my colleagues and I have had more bad results than successes A number of corneas have perforated, as I have said before; some of the scarring has been made definitely worse, and I can give a longer list of conditions of the eye which one should not treat with radiation than of those one should so treat

In regard to the dose, Dr Otto Glasser, of the department of biophysics, estimates that for us, it is the amount of radon substance in the glass vial which gives the number of treatment seconds to make 250 to 300 millicurie minutes, and the treatment usually runs twenty seconds. In the case of a very thin scar of the cornea, it is possible to give it one-half, rather than a full, twenty second treatment, otherwise, the reaction is too severe One can produce such an intense reaction that the scarring from therapy is as great as would have occurred originally Therefore, we give the patient three ten second doses and wait three months When the scar is very dense, we give the full treatment In several instances we have tried twice the amount and have run into trouble, it was in these cases that we had the corneal perforations

We have had recurrences of some of the vegetations in cases of vernal conjunctivitis, but they have not involved the entire lid, and we have been able to pick them up as individual plaques and treat them with the applicator The amount of scarring of the lid is minimal rather than maximal, and the eye is fairly comfortable after one or two applications In the case of large polypoid masses it is best to screen off the eye with lead, and we have always referred such patients to Dr U V. Portmann, of the department of therapy, he treats them and sends them back to us for the small marginal polyps and the individual polyps on the surface of the lid

I am perhaps a little pessimistic about corneal transplantation, for I probably do not do it as well as Dr Castroviejo—I am sure I do not—

perhaps I should remain pessimistic, so that those of us who are not so expert do not become too optimistic about the method

The ill results of radiation therapy are often designated by the patient himself. If the patient is satisfied and can see well enough to do what he wants to do and carry on a job, he does not want operation, and I do not urge him into it.

I thank Dr. Castroviejo for the discussion of the radiation therapy being used in Mexico. Apparently ophthalmologists there are farther along than we are. There are certain things with which I do not agree. I do not believe that gamma irradiation should be used for recurrent pterygium. Again, it is advisable at the start of treatment to make good notes on the lens, for in most cases changes in the lens occur. In our early cases we made good notes on the lens, for we were interested in finding out whether this type of radiation would produce changes in the lens, to date we have not found any. That does not mean that we shall not have any, for I agree with Dr. Martin that the late sequelae might discourage one from using this method at all. Most patients with corneal lesions have a certain amount of change in the lens, they, therefore, have a double defect—the corneal lesion and the changes in the lens. We used to spray radiation over the capillaries, contact radiation, when we were treating a fairly dense scar or a good-sized vessel, I agree with Dr. Castroviejo that the treatment should be instituted within seventy-two hours after the operation on the cornea has been completed. In closing, I might say it is advisable for the ophthalmologist to have some one beside him who knows radium and roentgen ray therapy. Most ophthalmologists are not aware of the hazards connected with radiation treatment. There is a hazard if too much treatment is used, there is a hazard to the patient who is not treated properly, and there is a hazard to the user of the radium, radium is not something one can use without due regard to what is being used for radium is a powerful substance.

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Brittain F. Payne, M.D., *Chairman*

Milton L. Berliner, M.D., *Secretary*

*Centennial Meeting, March 17, 1947*

PAPERS OF THE EVENING

**Past and Future Progress in American Ophthalmology** DR. DERRICK  
VAIL, Chicago

The past one hundred years has seen the origin, development and full flowering of American medicine and, with it, of ophthalmology. Arising as an offshoot of European science and transplanted to the new and free environment of the United States, American ophthalmology has flourished like the "green bay tree." It will continue to do so unless stifled or smothered by political, bureaucratic manure.

At first a country cousin, a sort of ridiculed yokel, American ophthalmology has at last reached maturity and has become a distinguished and respected contributor to world ophthalmology. The period of rapid, self-sufficient and manly growth began after World War I and accelerated shortly before and during World War II. The

reasons for this are many. First, there is the heritage handed down by the early great ophthalmologists, most of whom were trained during the golden age of European medicine, which is perhaps forever gone, second, the growth and influence of our dynamic ophthalmic societies, third, the impact of the American Board of Ophthalmology on all teaching of ophthalmology in this country, fourth, the increasing interest of many foundations in ophthalmic research, fifth, the growing opportunities for postgraduate training in this country, sixth, the impressive increase and significance of native ophthalmic literary and scientific contributions, seventh, the development and maturity of American ophthalmic journals, and, finally, the vigorous quality of the leadership of teachers in the medical schools, hospitals and medical centers of the country.

Seed planted in such fertile and rich soil is certain to sprout and be fruitful if it is properly tended, pruned, cultivated and enriched. Our future progress in ophthalmology in America must be dependent on the continuance of our program of teaching, training and instruction, on the fostering of every plan for the dissemination of knowledge through scientific meetings, free discussions, books, journals, instruction courses and, particularly and above all, the example, precept and integrity of our leaders. Our progress can only be wilted, sterilized and vitiated if, by our folly, we succumb to political machinations, to harmful, misleading and self-aggrandizing publicity, and to propaganda which is alien to the free development of our science.

#### History of Ophthalmology in Canada DR JOHN A. MACMILLAN, Montreal, Canada

A short introduction concerned the early history of medicine in Canada under the French and British régimes. This was followed by short biographies of the pioneers in the field of ophthalmology, including Henry Howard, Abner M. Rosebrugh, Richard Andrew Reeve, Frank Buller and Louis Edward Desjardins. Finally, the present endeavor to meet the demand for training in ophthalmology was discussed.

#### History of the American Board of Ophthalmology. DR S. JUDD BEACH, Portland, Maine

The American Board for Ophthalmic Examinations was organized in 1915. This is now the American Board of Ophthalmology. Ten years later the next examining Board, that for the ear, nose and throat, was launched. The idea of examining ophthalmologists and of issuing a certificate to be required for admission to the special societies originated with Edward Jackson.

Before the organization of the Board for Ophthalmic Examinations, no standards for graduate training were in effect. Residencies were without systematic teaching. Graduate courses covered no specified subjects. No attempt was made to examine students to find out what they had actually learned.

Requirements, established by the Board, have compelled the standardization of such casual graduate teaching. The Board has also furnished the public with a list from which safe ophthalmologists may

be selected, for this has always been the objective of the examination. From this pioneer project has developed the entire system of examinations in medical specialties, now numbering fifteen boards, coordinated by the Advisory Board of Medical Specialties.

### New York as an Ophthalmological Center DR BERNARD SAMUELS, New York

The first ophthalmic institution in New York was the New York Eye Infirmary, now the New York Eye and Ear Infirmary, founded in 1820. For thirty-two years it was the only institution of its kind in New York. In 1852 the New York Ophthalmic Hospital was founded, and since then seven others have come into existence. Each of these hospitals was named and briefly described in chronologic order.

Ophthalmology in New York was discussed under the headings of surgery, teaching, research and literature.

Reference was made to the benefits ophthalmology has derived from the Academy.

The conclusion was reached that New York is the foremost ophthalmologic center of the world.

### COLLEGE OF PHYSICIANS OF PHILADELPHIA, SECTION ON OPHTHALMOLOGY

Burton Chance, M D, *Chairman*

George F J Kelly, M D, *Clerk*

Feb 20, 1947

### Syndrome of Paroxysmal Lacrimation When Eating Associated with Paralysis of the Lateral Rectus Muscle (Gusto-Lacrimal Reflex of "Crocodile Tears") CAPTAIN FRANK C LUTMAN, Medical Corps, Army of the United States (by invitation)

Paroxysmal lacrimation when eating, which is occasionally seen as a sequel to peripheral paralysis of the facial nerve on the same side, is an abnormal form of reflex tearing accompanying salivation. The explanation for the abnormal facial movements following peripheral motor paralysis of the facial nerve and other pathologic associated reflexes is also applicable here. From all cases now available, the evidence suggests that this reflex tearing is established either by some of the regenerated axons to the salivary glands becoming misdirected to the lacrimal gland or by single axons at the point of the lesion branching and innervating both the lacrimal and the salivary glands. However, the center for this reflex, if peripheral, remains obscure.

Two cases were described. In the first congenital unilateral paroxysmal lacrimation when eating was associated with homolateral paralysis of the lateral rectus muscle. In the second there were bilateral paralysis of the lateral rectus muscle and bilateral reflex tearing when eating. A review of the literature on lacrimation when eating revealed a third case of the syndrome, with similar bilateral involvement. In all 3 cases the condition was first noticed in infancy.

It was suggested that the pathologic syndrome in these 3 instances was produced by a pontile lesion, involving the nucleus of the abducent

nerve and the superior salivary nucleus of the facial nerve, or by a lesion of the nucleus of the abducens nerve and the genu internum of the facial nerve as it passes around the nucleus of the sixth nerve

These 3 cases of paroxysmal lacrimation when eating associated with paralysis of the lateral rectus were presented as evidence of a new congenital neuro-ophthalmologic syndrome

As treatment, if the reflex tearing can be interrupted by cocaineization of the sphenopalatine ganglion, injection of alcohol into the ganglion offers a more permanent means of control. When indicated, the paralysis of the lateral rectus should be treated with tendon transplants from the superior and the inferior rectus muscles

#### DISCUSSION

DR ROBERT A GROFF Captain Lutman has presented an interesting and, so far as I am aware, a new syndrome when he adds to the familiar paroxysmal lacrimation during chewing movements a homolateral paralysis of the rectus muscle

I became interested in the syndrome without the associated palsy of the lateral rectus muscle six or seven years ago, when I saw a patient who teared whenever he ate an apple. This patient gave a history of a facial palsy, from which he had completely recovered eight or ten months before. As Captain Lutman suggested in discussing the treatment of this condition, I, at that time, injected procaine into the sphenopalatine ganglion and produced temporary cessation of the phenomenon during the time the drug was acting. Since this procedure was successful, the second injection was made, using 0.5 to 1 cc of absolute alcohol, and for about three months the patient was free from symptoms. After that he disappeared from the clinic, indicating perhaps that the difficulty did not return.

As to the association of the syndrome with palsy of the abducens nerve rather than of the facial nerve, I have had no personal experience. This syndrome is new, although I say it with hesitancy, not having reviewed the literature. I do not agree with Captain Lutman that the syndrome is caused by a central lesion. The tearing associated with lesions of the facial nerve has been rather definitely proved to be a peripheral reflex phenomenon. The possible pathways are the chorda tympani, the sphenopalatine ganglion, then through the zygomatic nerves to the lacrimal gland. It may be that in some way the fifth cranial nerve is involved, in view of the studies Dr Lewey and I carried out in connection with the Marcus Gunn phenomenon in which we demonstrated autonomic fibers in the branches of the trigeminal nerve which, when stimulated, caused movements of the eyelid after the third cranial nerve had been sectioned several weeks before. For this reason, and because a central lesion would necessarily have to be minute to produce this syndrome without giving other neurologic signs, the entire phenomenon could better be explained on the basis of a peripheral perversion reflex. Furthermore, the fact that relief was obtained by injection into the sphenopalatine ganglion tends to support this view.

I wish to thank Captain Lutman for the privilege of discussing this interesting presentation.

DR WALTER I LILLIE I assure Dr Lutman he has been fortunate in seeing so many cases during his short career in medicine, for they are rare indeed I was much interested in his paper, as I have only seen 1 case with paralysis of the lateral rectus muscle and lacrimation I feel as Dr Groff does, that it is a peripheral lesion Personally, I do not see how one could conclude that there is a pontile lesion in the region of the nucleus of the abducent nerve where the knee of the seventh nerve passes around it The pons is a small portion of the central nervous system A lesion large enough to include both the genu of the seventh nerve as it curves around the nucleus of the sixth nerve and the salivary center would produce many contralateral motor and sensory disturbances, and that, to my knowledge, has not occurred

CAPTAIN FRANK C LUTMAN, Medical Corps, Army of the United States With Dr Lillie and Dr Groff, I also believe that this is a peripheral reflex A lesion of the pontile facial nucleus would produce peripheral facial paralysis, which, as I brought out in the paper, is a requisite for development of this type of paroxysmal lacrimation As I understand Dr Groff's contention, it would require two lesions to explain a combined paralysis of the abducent and the facial nerve To my mind, it would be simpler to attribute this to a single lesion and the point where the facial and the abducent nerve are closest together is in the pons

However, as has been mentioned, this tearing is rather complicated and I hope that in future cases a careful neurologic examination will be made

**Syndrome of Meningeal Fibroblastoma Arising from the Lesser Wing of the Sphenoid Bone: Analysis from an Ophthalmologic Standpoint** DR ROBERT H TRUEMAN

The historical aspects of suprasellar and parasellar meningiomas were considered, with particular emphasis on the early observations of those arising from the sphenoidal ridge

The terms suprasellar and parasellar were defined, with a description of the sphenoidal ridge The anatomy of the region of the lesser wing of the sphenoid bone and the sella turcica was reviewed, and the pathologic picture of meningioma was discussed

The syndrome of early meningioma of the lesser wing of the sphenoid bone was described as atrophy of the optic nerve, changes in the visual fields, exophthalmos, involvement of ocular motility, sensory disturbances in the distribution of the first and second divisions of the trigeminal nerve and involvement of taste and smell, all on the side of the tumor Further changes in these symptoms and signs with growth of the tumor were mentioned, as well as the appearance of symptoms and signs of involvement of the pituitary gland and the frontal lobe and sensory and motor alterations

The symptoms in 56 cases were analyzed to show that in 82 per cent of them the first symptoms to appear were ocular The various forms were discussed

The objective findings were then analyzed to show that in 91 per cent of cases there were changes in the fundus, in 86 per cent changes in the visual fields, in 43 per cent exophthalmos and in 38 per cent involvement of ocular motility. The findings other than the ocular signs were then discussed, including trigeminal paresthesias, signs of pituitary disturbance, involvement of taste and smell, signs referable to the frontal lobe and sensory and motor changes.

The roentgenographic picture was then discussed, with particular reference to the generalized and the localized changes, which include the erosions and the local and general hyperostoses.

The differential diagnosis of intraorbital tumors, intrasellar tumors, aneurysms, optochiasmic arachnoiditis, gliomas and craniopharyngioma was discussed.

In conclusion, the syndrome was redefined, with the early and late clinical findings.

#### DISCUSSION

DR ROBERT A. GROFF: Dr. Trueman is to be congratulated on his excellent presentation. Certainly, he has clarified the syndrome since Dr. B. J. Alpers and I first called attention to it, several years ago.

The successful surgical removal of these tumors depends on early diagnosis, for the technical problem is then simplified greatly. The lesion is small, and, as a result, the opportunity of complete removal is much more favorable.

The picture presented here includes that in cases of late diagnosis. In fact, in some of the cases the diagnosis was made at a time when the tumor was inoperable. Let me state the early signs, which are sufficient to make the diagnosis. Early primary optic nerve atrophy or papilledema, a cut in the visual field on the temporal side of the affected eye and a sella turcica at the upper limit of normal size are all that is necessary to justify one in demanding encephalographic studies to verify the diagnosis.

When unilateral exophthalmos is developing in a patient, the possibility of meningioma of the lesser wing of the sphenoid bone should be excluded first. Roentgenograms of the skull will aid in the diagnosis, for, in my experience, the sphenoidal ridge shows definite thickening incident to tumor infiltration.

At operation these tumors present an interesting picture. The meningioma in this location is one of two types: a bulbous growth or an en plaque type, in which the tumor is flat and spreads over the surface of the dura. The latter type is usually associated with underlying infiltration of bone, which produces exophthalmos.

In order to cure the patient, it is necessary to remove the dura to which the tumor is attached. The bulbous variety offers a much less technical problem than the tumor which grows by spreading over the surface of the dura. The former, therefore, if not large, can usually be removed completely. The latter is almost never removed completely and therefore recurs. Since this type of tumor is of rather slow growth, it is usually several years before a second operation is necessary.

When the bone has been invaded by the tumor, it is practically impossible to remove all the involved bone because of the adjacent



structures—the internal carotid artery, the nasal chamber and sinuses and the superior orbital fissure. Although a routine decompression of the orbit is done in cases of exophthalmos, it relieves this sign only partially.

Dr Trueman stated that the cause of the exophthalmos is probably venous engorgement. This explanation seems most likely, because the structures of the orbit are edematous and under tension, as though there was obstruction to the venous drainage system.

A plea is made for the early recognition of these tumors. As Dr Trueman has stressed in his paper, when a patient comes with slight primary atrophy of the optic nerve, a temporal field defect in the same eye and roentgenographic evidence that the pituitary fossa is of normal or upper normal size, he should be studied without delay for the possibility of a tumor of the lesser wing of the sphenoid bone.

DR WALTER I LILLIE. I should like to go one step further in discussing the early stage of the ocular syndrome.

An early sign is the retrobulbar neuritis syndrome on the side of the lesion, that is, lowered visual acuity, a central scotoma and otherwise normal findings. This is the ideal time for the diagnosis to be made, as it permits the neurosurgeon to enter and remove the tumor before it has been of long enough duration to have produced atrophy of the optic nerve. Optic atrophy is irreversible, a fact which I wish to stress even more strongly than Dr Groff did.

The ophthalmologist sees the patient first, and is the one responsible if there is delay in reaching the neurosurgeon. In the early stages the fundus is usually normal, and it is necessary to differentiate the lesion from an inflammatory or toxic condition. Against that diagnosis, as Dr Trueman brought out and Dr Groff has stressed, is the insidious onset, and slowly progressive character. These features speak for tumor rather than for inflammation or vascular lesion. I feel that in these cases a thorough neurologic examination is necessary, and should be requested by the ophthalmologist. I also strongly advocate making an encephalographic study early, for I believe that it is helpful to look for basal arachnoiditis in the sulcus chiasmatis, for lesions of the sphenoid ridge, calcification and a mass type of space-taking lesion. I concur with both Dr Trueman and Dr Groff, except I feel that it is necessary to detect the earliest ocular syndrome, and not wait for the appearance of optic nerve atrophy.

DR BURTON CHANCE. I am reminded by this history of a case of my own. I had been consulted by a lawyer who was engaged in a suit concerning the death of a woman after the collision of the automobile in which she was riding with her family with a horse-drawn vehicle. Photographs made by bystanders confirmed the transportation company's contention that the company was not at fault, nevertheless, a verdict was entered against the company.

Before the injured woman's death, it was declared that her sight had been destroyed, and that she was blind. I succeeded in obtaining the record books of an ophthalmologist, then deceased, who, eleven years before the accident, had been consulted by the woman. He recorded that she was blind in her right eye, because of complete atrophy of the optic disk, which he regarded as resulting from the

high degree of progressive myopia in each eye. At that time there were no roentgenographic facilities, and further study was not made. In opposition to the plaintiff's family, an autopsy was obtained. Attached to the sphenoid bone was observed a tumor about the size of a large white grape, extending by erosion into the orbit. Sandlike changes were felt over the surface of the tumor. By some strange slight of hand, the tumor was spirited away and was never recovered.

DR ROBERT H. TRUEMAN: Dr. Groff and Dr. Lillie have both emphasized, as I have tried, the importance of the early changes in the diagnosis of this tumor.

I should like to call attention to the fact that this analysis includes cases representing all sizes of these tumors, from the largest, in the early Cushing series, to the smallest, in the series of Groff and of Elsberg and Dyke. This variability in size explains the various types of clinical pictures, from the very early changes in the fundus and field to bilateral blindness. While it is important to recognize the very early changes, one should know that as the tumor grows progressive changes occur, for it is possible that a case might just as well be seen late as early.

I should like to ask Dr. Lillie a question. In his experience, has he ever been able to pick up a case of meningioma of the lesser wing of the sphenoid bone in which there was only a central scotoma?

DR WALTER I. LILLIE: Yes, I have.

DR ROBERT H. TRUEMAN: That answers my question. Thank you.

### Protection and Maintenance of Night Vision for Military Personnel.

DR ROBERT H. PECKHAM

This paper is a report of the recommendations and research performed by the Vision Committee of the National Defense Research Committee for the military services during the war. The author acted as liaison officer between the Committee and the Bureau of Medicine and Surgery.

As a result of the deliberations of this group of civilian and uniformed scientists, the following action was undertaken by both the Army and the Navy:

1. All personnel were instructed in the use of the eyes at night, with especial attention to waiting for dark adaptation and to using the rods of the retina by "looking around things."

2. An attempt was made to supply night combat personnel with red goggles, to preserve dark adaptation and to permit the attainment of adaptation in lighted compartments.

3. All Navy personnel were examined to eliminate night-blind persons.

4. As a result of directed research, it was decided that sunglasses were necessary for day wear, to permit best night vision. These sunglasses were neutral in color, not green or amber, of 10 per cent transmission and polarized, with the plane of transmission vertical. Finally, no specification against transmission in either ultraviolet or infra-red light was included.

5 The facts learned during the war can be applied to peacetime pursuits. Since the effect of sunlight is to reduce the sensitivity of the retina, sunglass protection is recommended for fluoroscopists. The effect of sunlight is to reduce the efficiency about 30 per cent. Sunglasses are needed by all persons engaged in colorimetry or any visual task involving comparative judgment. The effect of sunlight reduces retinal efficiency by from 20 to 50 per cent, depending on the task.

In the determination of avitaminosis by measuring the course of dark adaptation, the effect of previous exposure to sunlight could conceivably be so great as completely to confuse the readings. Exposure to sunlight can be effective as long as three weeks after the period of exposure, hence, the effect of vitamin therapy can be lost to demonstration.

All persons driving in dusk and at night after a day in unprotected sunlight will lose at least half their night visual efficiency, thereby rendering their driving dangerous, uncertain and fatiguing.

#### DISCUSSION

DR BURTON CHANCE. In commenting on the statement that persons exposed for long hours in the glaring sunlight were found to have distinct loss of power at night, I have noticed on my repeated visits to tropical islands that my native friends seldom enjoyed walking out with me at night, because they declared they could not see well at night. Visitors from northern climates have been impressed by the suddenness of nightfall—it is as though the sun had suddenly dropped out of the heavens and darkness was instantaneous.

On long voyages, as once on a sailing ship, before I entered ophthalmology, I noted how sailors, who had been most capable during the daylight hours, became less efficient during the night, especially after the periods in which their daytime watches were prolonged.

In World War I, at my Army hospital, located at the seaside, men from northwestern climates, who delighted in spending all the daylight hours on the beach, preferred to remain indoors at night. I believe that the daylight glare interfered with the photochemical reactions in the retina.

DR WALTER I. LILLIE. I should like to have a word before Dr. Peckham closes. One reads so often in the newspapers that the Negro race, the yellow race and the brown race have much better night vision than the white race. I wonder whether any of his investigations would prove or disprove such statements.

DR ROBERT PECKHAM. My associates and I made many measurements designed to distinguish racial differences. The first were made by the Army for the purpose of selecting drivers of trucks and jeeps under black-out conditions. Members of the Negro race were deliberately chosen because it was suspected that, being highly pigmented, they would have deeper choroidal pigmentation and be better able to see at night. The tests showed no difference. Many more careful and extensive tests were made during the war, until it was finally concluded that no one race showed any superiority of retinal sensitivity.

Persons of some races were better able to perform out of doors at night, being better trained for night vision because of their savage

environment At one time early in the investigations, we got a hurry-up call from the British that it had been suggested that the Japanese were night blind Because they were myopic, something ought to be the matter with them Fortunately, a few records of retinal sensitivity were available from Japanese students, and these showed no differences in retinal sensitivity

During the Pacific campaign, the Marines reported hearing Japanese broadcasts to the effect that the American Marines should stay indoors at night It was purported that certain selected Shinto fighters had been chosen for operations on the retina including the injection of secret drugs, and were then trained to be night killers These persons, it was boasted, had such tremendous retinal sensitivity that they could not go out of doors in the daytime, and therefore would not be seen This sounded like a fairy tale, but it had to be investigated It was concluded that it was a falsehood, invented by the Japanese because they had discovered that they had actually lost their night retinal sensitivity They had occupied the islands for months, and even years, waiting and watching for us to come We knew they were aware of their loss of night vision, for we found their foxholes literally lined with boxes of vitamin A concentrates We had ourselves tried such concentrates and found that they were useless to replace lost retinal sensitivity Only time, and considerable time at that, will permit the retina to regain its lost sensitivity

## Book Reviews

**Proceedings of the All-India Ophthalmological Society** Vol VIII  
Pp 176 Madras Publishing House, Ltd, Mount Rd, Madras, 1945

The eighth meeting of the All-India Ophthalmological Society was held at Hyderabad, Deccan, on March 8 to 10, 1945, under the presidency of Dr E V Srinivasan, of Madras

The president, in his introductory address, listed transplantation of the cornea, gonioscopy and penicillin therapy under the head of recent advances. Twenty-four communications, on a great variety of clinical subjects, were presented. Glaucoma occupied the principal place and was discussed under the headings of etiology, symptomatology, treatment, Bengal epidemic dropsy glaucoma, secondary glaucoma and glaucoma and gonioscopy

ARNOLD KNAPP

**Transactions of the Ophthalmological Society of Australia (British Medical Association)** Volume 4 Pp 212 Price, 7s 6d Sydney, Australia Australasian Medical Publishing Company, Ltd, 1944

This is a report of the proceedings of the Ophthalmological Society of Australia in the first meeting held in three years, on Oct 12, 1944, in Melbourne. The presidential address was delivered by Dr G B Black, who succeeded to office on the death of the president, Dr J L Gibson.

E C Black discussed ocular injuries in industry, reporting 10 cases of various injuries, with special reference to accidents occurring on railroads. Articles on lighting, particularly in industry, were read by L D Wright, who made a plea for medical leadership in this project, and by A L Tostevin, who called for a visual survey of school children.

Certain ocular disorders found in the tropics were listed in papers by J A Pockley, K B Armstrong and Clifford Colvin. The diseases described by the first two authors (among which were dendritic ulcer, quinine amblyopia, melanoma of the choroid and dacrycystitis) are not particularly confined to the tropics, although Pockley mentioned that scrub typhus may be accompanied with thrombotic changes in the retinal vessels, subconjunctival hemorrhage and corneal ulcer.

Colvin, however, confined his report to conditions indigenous to the tropics. He stated that he had encountered dendritic ulcer, hyperemia of the disks and retinal hemorrhages with malaria, painful ocular movements and sustained asthenopia with dengue, iritis with relapsing fever and dysentery, and corneal tumors with leprosy. Herpes simplex of the cornea occurring in patients with malaria was described by W P Chamberlain and L H Bronson, medical officers in the Army of the United States. They reported six times as many cases of such corneal involvement in a malarial division exposed to malaria as in a division not so exposed. They recommended local application of sulfadiazine powder to the lesion.

Lessons to be learned by ophthalmologists from the war were summarized in a thoughtful paper by J B Hamilton. His suggestions included utilization of opticians in private practice, an improved supply of ophthalmic nurses, an increase in special hospitals for ocular diseases,

the establishment of private ophthalmic clinics in the larger cities, ophthalmic training for discharged medical officers and the stimulation of laboratory and research work by the society. Hamilton also read a paper on tuberculous lesions of the eye. His classification follows:

- 1 Undoubted infection of the globe with tubercle bacilli
  - (1) Uveitis with mutton fat keratic precipitates and Koeppe nodules
  - (2) Uveoparotid fever
  - (3) Conglomerate tuberculosis of the retina
  - (4) Miliary tubercles on the retina associated with fulminating miliary tuberculous meningitis
- 2 Tuberculous lesions of the globe in immune desensitized persons
  - (1) Heterochromic cyclitis with or without complicated cataract
  - (2) Disseminated choroiditis with loss of pigment
  - (3) Retinal periphlebitis with hemorrhage in the vitreous and retinitis proliferans—Eales' disease
- 3 Tuberculous lesions of the globe in immune sensitized persons Phlyctenulosis
- 4 Doubtful tuberculous lesions of the globe
  - (1) Interstitial keratitis
  - (2) Sclerosing keratitis
  - (3) Episcleritis and scleritis
- 5 Pseudotuberculous lesions, Boeck's sarcoid

He stressed the value of a history of contact and urged removal of the patient from his or her source of infection.

There were four papers on congenital cataract associated with rubella in the mother. Ida Mann, summarizing the observations already made (which, incidentally, originated chiefly in Australia), pointed out that the period of susceptibility of the lens is between the first and the second month. She wisely stated:

It has never been the custom for physicians to make searching inquiries concerning illnesses occurring at the very beginning of pregnancy. This, undoubtedly, should be done in every case of congenital abnormality, when it may well be found that a variety of causes other than rubella operating during the first six weeks may produce congenital cataract and heart disease. If such congenital disorders should be found specific for rubella, it would be surprising from the embryologic point of view. Meanwhile, the observations stand for an important advance in the correlation of experimental and clinical findings.

N McA Gregg added to his previous contribution (Congenital Cataract Following German Measles in the Mother, *Tr Ophth Soc Australia* 3:35, 1941) and listed certain problems still to be solved— isolation of the virus of rubella, development of prophylactic and curative treatment, more publicity in order to prevent infection of the potential mother, and care and treatment of the defective child resulting from the disease. Similar observations and recommendations were given by Charles Swan. F V Scholes, medical superintendent of the Hospital of Infectious Diseases, brought up the interesting point that other virus diseases, notably measles, may, if sufficiently severe, produce similar fetal malformations.

In a paper on "Crossed Cerebral Dominance" (in which the master hand and the master eye are on opposite sides), J R Anderson and

C Weigall made this difficult and important subject clearly understandable to the ophthalmologist. The whole article should be read, but their conclusions are as follows:

1 Most children demonstrate naturally a preference for one or the other hand. This preference appears to be inherited. It requires practice before it becomes fixed. The strength of its fixation varies greatly with the individual. In some persons transference of mastery to the other hand is difficult, while in others it can occur without upset.

2 The dominance of one eye is probably also inherited.

3 The occurrence of crossed dominance is likely to be associated with nervous symptoms. In addition, difficulty in learning to fly, in playing games, and even in routine school work, is sometimes experienced. These, and crossed dominance, are more probably concomitant signs of an imperfectly integrated nervous system than the results of crossed dominance.

4 Ocular dominance may affect the prescription of lenses if both eyes are open while the nondominant eye is being tested.

5 Difficulty in developing fusion is the rule in persons with convergent squint if crossed dominance is present.

6 It appears that if crossed dominance is always an obstacle its influence may be obscured by special development of such qualities as determination, enthusiasm and physical fitness.

7 Not only physical but emotional and intellectual gains may follow the careful unilateralization of ocular and manual dominance in selected persons.

Other, and shorter, articles in the volume were those by A. Joyce, who reported a case of glaucoma of the retina cured by the implantation of a radon seed, by N. M. MacIndoe, who advocated the cure of dacryostenosis by inserting a small rubber tube in the lower end of the lacrimal sac and placing it in an opening into the nose (the tube was subsequently removed), by J. L. R. Carter, who described his procedure—apparently the universal one—of probing for infantile dacryostitis, by K. O'Day, who wrote somewhat inconclusively on the color of the human iris, by E. V. W. Pockley, who stated the advantages of intracapsular cataract extraction, by A. d'Ombrian, who stated that he prefers making his cataract incision with a keratome, and by L. Gilchrist, who recommended partial occlusion in the treatment of amblyopia ex anopsia.

An article on repair of the eyelids and periorbital structures was contributed by B. K. Rank, who apparently is a plastic surgeon rather than an ophthalmologist.

Taken as a whole, this volume can be read with pleasure and profit and clearly indicates that Australian ophthalmology is in the first rank.

G. M. BRUCE

**Transactions of the Ophthalmological Society of Australia (British Medical Association)** Volume 5 Price, 7s 6d Pp 143 Sydney, Australia, Australasian Medical Publishing Company, Ltd, 1946

In this volume are reported the proceedings of the fifth general meeting of the Ophthalmological Society of Australia, held in 1945. The opening address was delivered by the president, N. McAlister Gregg.

In a lengthy, but well arranged, paper (which takes up about one third of the volume) C G McDonald discusses diseases of the arteries and their relation to the eye. He suggests that the word "arteriosclerosis" should be abandoned, as it is too general a term. He believes that when the subintimal layer of an artery is diseased "atheroma" is the term to be employed. This condition is rarely detected in retinal vessels but may coexist with "essential hypertension" (hypertensive vascular disease). The latter is the dominant disease of arteries. McDonald divides this disease into three stages: (1) functional vascular hypertonus, (2) vascular and visceral reactions—cardiac hypertrophy, medial hypertrophy of small vessels and diffuse hyperplastic sclerosis of visceral vessels, and endarteritis obliterans—and (3) visceral failure—cardiac defeat, cerebral vascular accidents and renal failure. "Malignant hypertension" (rapidly progressive hypertensive vascular disease) he discusses separately, although he is not convinced that it is a separate entity from hypertensive vascular disease. In fact, he believes that all cases of hypertensive vascular disease will become rapidly progressive if the diastolic pressure rises high enough. Nephritis he classifies as (1) acute focal glomerulonephritis, due to a primary infection elsewhere, usually in the throat, (2) acute focal embolic glomerulonephritis, occurring in the course of subacute infective endocarditis, (3) acute diffuse glomerulonephritis, also due to a focal infection but later in onset, (4) subacute diffuse glomerulonephritis, with gross albuminuria but without elevation of blood pressure, and (5) chronic diffuse glomerulonephritis, the familiar chronic stage.

In describing the fundus oculi in hypertension and nephritis, he contributes little that is not already known to ophthalmologists. He believes that no differentiation can be made ophthalmoscopically between the retinal picture of hypertension and that of nephritis. However, he also states that diabetic retinitis cannot be diagnosed with the ophthalmoscope.

P L Spero discusses some ocular manifestations due to malnutrition as seen in returned prisoners of war recently released by the Japanese. He examined 64 patients. He states that the most frequently encountered ocular lesion was retrobulbar neuritis followed by partial atrophy of the optic nerve affecting the papillomacular bundle. His observations are confirmed and added to by F P Claffy, who had himself been a prisoner of war for three years. He had discovered that retrobulbar neuritis and corneal degeneration followed deprivation of vitamin B complex, and partial ophthalmoplegia resulted from the absence of thiamine. He found impairment of vision (from 6/5 to counting of fingers), fine nystagmoid movements, occasional mild papillitis, going on to temporal pallor, rare retinal hemorrhages, paracentral or central scotomas (relative or absolute), and normal peripheral fields. The prognosis depended on the amount of atrophy that had supervened. While frank corneal ulceration occasionally was encountered, more frequently a noninflammatory diffuse superficial degeneration occurred. Permanent opacification was rare.

Darcy Williams speaks of the fitting of contact glasses, describing a technic which is similar to that used in the United States.

Three cases of toxoplasmic encephalomyelitis and chorioretinitis are reported by E G Robertson and J B Hamilton. All the patients



were girls, aged 13, 5 and 16 years, respectively. One had convulsions, 1 was of below normal intelligence, and the other, an inmate of an institution, was unable to read or write. All had choroidal changes, and calcified deposits were demonstrated in the roentgenograms.

Granville Waddy reports a new ocular syndrome, consisting of poor vision (6/60 to 6/36), nystagmus, albinoid fundi and a high degree of intelligence. He had 8 or 10 patients with this syndrome.

There are papers on ocular sarcoidosis by H. Ryan and W. D. Counsell and by the latter author with J. B. Hamilton. In all, 3 cases are reported. Conservative treatment is advocated, as the outlook is good. Every effort should be made to distinguish Boeck's sarcoid from tuberculosis.

In discussing the treatment of secondary cataract, E. T. Smith states that early iridectomy is indicated. If extraction is too long delayed, the eye may degenerate. An interesting feature of this paper is an account of the ocular vicissitudes of James Joyce, whose eyes were operated on more than seven times for cataract secondary to iritis.

F. G. Roberts' patients had distressing psychologic reactions following cataract extractions, and he advocated obtaining a state of complete "non-cooperation" in every case. In a paper entitled "Premedication and Cooperation in Cataract Extraction," he suggests giving the patients sodium amytal and eliminating the movements of the eyeball by injection of procaine. The eye could be turned downward by stitches inserted into the superior rectus or on each side of the cornea. In the ensuing discussion, there was evident a courteous lack of enthusiasm over this technic.

Prolapse of the iris, according to N. M. McIndoe, is less likely to occur after a simple intracapsular extraction followed by suturing of the wound, instillation of physostigmine and ample postoperative sedation. The prolapsed area should be immediately incised and replaced. Cautery is contraindicated.

Arthur D'Ombrian believes that traumatic monocular glaucoma is a clinical entity. He lists 18 cases, in all of which three common factors were present: (1) a history of trauma, (2) glaucoma in one eye and (3) absence of glaucoma in the other eye. He suggests that some types of concussion shock can upset the stabilization of intraocular pressure.

C. H. B. Black reports 3 cases of keratitis which he believes were due to deficiency of ascorbic acid. He asks for further clinical investigation of the subject by others.

A case of septic thrombosis of the cavernous sinus is reported by R. G. Banks-Smith. After severe headache and delirium, double proptosis appeared, and there was venous engorgement in one fundus, the other being invisible because of edema. The patient recovered under penicillin and sulfonamide therapy, with normal vision in one eye but with atrophy of the optic nerve and blindness in the other.

The volume ends with an obituary of the late Sir James Barrett. This olympian figure, one of the great men of the Empire, had begun his career as an ophthalmologist.

G. M. BRUCE

## POSTOPERATIVE COMPLICATIONS OF CATARACT EXTRACTION

WILLIAM F HUGHES Jr, M D  
CHICAGO

AND

WILLIAM COUNCILMAN OWENS, M D  
BALTIMORE

IN A PREVIOUS paper,<sup>1</sup> based on a survey of 2,086 operations performed under similar conditions but with different operative technics, we compared the results of various technics used in cataract extraction. It was found that the majority of postoperative complications were related to the type of operation used rather than to the general systemic condition of the patient. Such data immediately indicated certain surgical procedures which could be expected to obviate many of the postoperative complications. In the present paper we have reviewed all these complications with the idea of determining the most effective measures for their prevention and treatment. Unfortunately, the various methods of handling postoperative complications cannot be evaluated statistically in most instances because of the multiplicity of causes and the relatively few instances of each complication.

### POSTOPERATIVE COMPLICATIONS OF CATARACT EXTRACTION

*Incomplete Closure of the Wound*—Delayed closure of the corneal incision was noted in 63 cases of this series, occurring most commonly when vitreous had been lost. This complication was almost completely prevented by the use of two McLean silk corneoscleral sutures.<sup>1</sup> The experimental use of surgical gut corneoscleral sutures has proved less satisfactory in our hands than that of silk sutures. Plain surgical gut sutures were usually absorbed soon after the fifth postoperative day,

From the Wilmer Ophthalmological Institute of the Johns Hopkins University and Hospital

A summary of this paper was read before the Section on Ophthalmology at the Ninety-Fifth Annual Session of the American Medical Association, San Francisco, July 5, 1946

1 Hughes, W F, Jr, and Owens, W C. Extraction of Senile Cataract. Statistical Comparison of Various Techniques and the Importance of Preoperative Survey, *Am J Ophth* 28 40, 1945

and complications incident to gaping of the wound often ensued. Chromic surgical gut sutures were used in a few cases to retard absorption. However, they were difficult to place prior to the section because of their inflexibility, they produced a greater postoperative reaction and in some cases required weeks to absorb completely.

When incomplete closure of the wound occurred, the necessity of secondary operative repair depended largely on whether vitreous or capsular material had been caught in the lips of the gaping wound. Of 47 cases without protrusion of vitreous, the use of a conjunctival flap or of additional corneal sutures was necessary in only 5. On the other hand, in 12 cases in which there were exposed blebs of vitreous further operative treatment was required. In 3 of the latter heat cauterization alone was sufficient to close a defect of less than 3 mm. but failed in 3 cases with wider gaping. In 9 cases a conjunctival flap or additional corneal sutures were required.

*Prolapse of the Iris*—Prolapse of the iris occurred in 56 cases in this series. In 75 per cent of the cases the prolapse was small and well covered with conjunctiva. It is interesting to note that in 43 per cent of cases the prolapse did not occur until after the eleventh postoperative day and that in 1 case it did not appear until six months after the extraction. In these cases of late prolapse the iris was usually adherent to the posterior lip of the corneal wound at the time of the patient's discharge from the hospital.

The major etiologic factor appeared to be incomplete closure of the corneal wound. Prolapse occurred in 21 per cent of cases with gaping wounds, in contrast to 3 per cent of 2,000 cases without detectable separation of the wound. The preservation of a round pupil has often been thought to increase the likelihood of later prolapse. However, with corneoscleral sutures, the incidence of prolapse of the iris after round pupil extractions with iridotomy was the same as that after extractions combined with a full iridectomy. In the few cases of round pupil extraction without peripheral iridotomy prolapse was frequently encountered. Occasionally at operation it was difficult to reposit the iris because of the tendency of bulging vitreous to force the iris into the wound and in such cases there seemed to be a predisposition to prolapse. Loss of vitreous at the time of operation was not a predisposing factor. The use of one, and especially two, corneoscleral sutures at operation reduced the incidence of prolapse of the iris.<sup>1</sup>

Small prolapses, in which a nubbin of iris, 1 to 2 mm. in size, was visible beneath an intact conjunctival flap, were frequently not repaired. In a few instances, intensive use of miotics prevented further herniation of the iris and the wound healed satisfactorily. However all large prolapses or prolapses in which the iris tissue was not covered with conjunctiva were excised. The technical difficulties were least when the operation was performed within a few days after the prolapse had

occurred, when an intact conjunctival flap was present over the prolapse or when the corneal wound was securely closed, either with the original corneoscleral sutures or by normal healing. Corneoscleral sutures were essential in repairing the wounds if there was wide gaping, if a conjunctival flap could not be mobilized easily or if vitreous had presented.

There was no demonstrable difference in the final visual result in cases of small covered prolapses in which there was no operative intervention and those in which there was complete excision, in cases in which the wound was closed with a conjunctival flap and cases in which a corneal suture was used, and cases in which there was immediate and cases in which there was delayed repair.

*Delayed Reformation and Late Loss of Anterior Chamber*—The anterior chamber was flat at some time during the postoperative course in 66 cases. In 21 per cent of these cases the anterior chamber was collapsed at the time of the first dressing, in 30 per cent the anterior chamber was formed at the first dressing but subsequently was lost. In 32 per cent the chamber was lost at the time of removal of the corneoscleral sutures, and in 17 per cent it collapsed the day after removal of the sutures.

One constant etiologic factor contributed to the delayed reformation and to late loss of the anterior chamber, namely, filtration of aqueous through the corneal incision. In the majority of the cases there was direct clinical evidence of such filtration. Gaping of the corneal incision was detected in 10.1 per cent, a filtering bleb of the conjunctiva was present in 7.2 per cent, a tear in the conjunctival flap was noted in 2.9 per cent, and loss of the chamber during or after removal of sutures occurred in 4.9 per cent. However, no obvious reason could be found to explain 9 cases of nonreformation of the chamber. It is probable, however, that in these 9 cases some filtration might have been taking place around a deeply placed suture tract, for the anterior chamber has frequently been found to deepen after the removal of corneoscleral sutures.

Loss of the anterior chamber following removal of corneoscleral sutures can be partially averted by precautions taken in the placement and removal of the sutures. The sutures should not be placed too deeply, but with long, superficial bites into the sclera and the corneal lips of a somewhat shelving notch. In general, such sutures should not be removed before the tenth postoperative day. In removing the sutures, adequate topical anesthesia is essential, and akinesia of the lids is sometimes necessary. The point of a sharp iris scissors should be directed away from the wound (either up or horizontally). The suture should not be grasped with forceps until it has been cut, so that the wound will not rupture if the patient unexpectedly moves his eye. A Graefe knife can be used to cut the sutures. If the sutures are deeply placed or if the patient is uncooperative removal

of sutures should be postponed until a week or two after discharge from the hospital, when they can be removed more easily

Treatment of a flat anterior chamber is directed toward closure of any filtering point in the wound and the use of measures to prevent peripheral anterior synechiae. Application of a pressure bandage is sometimes adequate to close a small filtering bleb. More pronounced gaping of the corneal wound or rents in the conjunctival flap may have to be repaired. In cases in which the chamber spontaneously becomes shallow after the eighth postoperative day, it is sometimes advisable to remove the corneoscleral sutures. To prevent the formation of peripheral anterior synechiae, the pupil is kept mobile by the alternate use of mild mydriatics and miotics, for the most part it is kept constricted with miotics.

Air was injected into the anterior chamber in some cases in which the chamber remained collapsed for seven to ten days. This was done by making a slanting incision with a Ziegler knife through clear cornea. Then a short 25 gage needle on a 2 cc hypodermic syringe was inserted through this opening and sufficient air injected to reform the anterior chamber and to break up adhesions. The procedure is not without possible complications, the most important of which is a breakdown of the freshly healed incision, with hemorrhage into the anterior chamber or prolapse of the iris resulting. Accidental injection of air into the corneal stroma is of no consequence. Injection of air into the anterior chamber successfully reformed the chamber in all of the 5 cases in which it was used in this series, but peripheral anterior synechiae, visible without gonoscopic examination, persisted in 2 cases.

The formation of peripheral anterior synechiae as a result of collapsed anterior chamber is generally considered to be a predisposing factor in the production of secondary glaucoma. In 23 cases with flat anterior chambers for over seven days, secondary glaucoma ensued in 17.4 per cent, in contrast to an incidence of 4.3 per cent of 2,062 cases without prolonged absence of the anterior chamber. This difference is suggestive of an etiologic relationship, but it is not statistically significant.

*Persistent Haziness of the Cornea*—It is our impression that "striate keratitis," or wrinkling of Descemet's membrane, more commonly follows the technic of intracapsular extraction with corneoscleral sutures than earlier technics of extracapsular extraction without corneoscleral sutures. Such postoperative edema of the cornea is usually transitory, disappearing within two or three weeks after operation. However, persistent corneal haziness was sufficient to reduce final vision below 20/30 in 11 cases (0.5 per cent). No single etiologic factor can be isolated, but it appears that excessive instrumentation at the time of operation, trauma in the placement of sutures, postoperative iridocyclitis and poor closure of the wound are prominent factors. These factors may lead

to such damage to the corneal endothelium and so prevent its normal regeneration that edema of the cornea persists. It is interesting that in 2 cases with Fuchs's dystrophy, 3 cases with inactive interstitial keratitis and 7 cases with other types of preoperative corneal scarring no increase in the corneal opacities followed cataract extraction. To reduce the trauma during the placement of corneoscleral sutures, 000000 braided silk on atraumatic needles<sup>2</sup> has been used. If the suture tract is excessively long, the suture should not be tied too tightly, or a "surgeons' knot" should be used to avoid undue wrinkling of the cornea.

*Hemorrhage into the Anterior Chamber*—In this series, postoperative hemorrhage into the anterior chamber occurred in 195 cases. In 71 cases the hemorrhage either filled the anterior chamber or was recurrent. In addition, hemorrhage followed the removal of corneoscleral sutures in 3.6 per cent of 1,030 cases in which they were used. These cases have been reported elsewhere<sup>3</sup> and the following is a summary of these reports.

Our data support the general thesis that hemorrhage in the anterior chamber results from rupture of new-formed capillaries in the healing wound. The incidence of hemorrhages was significantly low for those extractions in which the Graefe section was placed almost in clear cornea, such wounds probably healing with less vascularization. Hemorrhages occurred least frequently when two corneoscleral sutures were used to secure firm closure of the wound. Extensive hemorrhages were more prone to occur in patients with severe or long-standing diabetes, but the height of the blood sugar was not an important factor.

Various conservative measures of treatment, such as hot or cold compresses, did not appear to influence the absorption of blood appreciably. Blood lying on the iris was absorbed more rapidly than blood either lying on capsular remains or mixed with vitreous.

The final visual results were somewhat poorer in the cases with postoperative hemorrhage in the anterior chamber, principally because of persistent opacities in the vitreous, a result of seepage of blood from the anterior chamber into the vitreous.

*Expulsive Hemorrhage*—From a survey of the literature and our own 3 cases, little or no correlation is apparent between systemic hypertension and expulsive choroidal hemorrhage. Age, perhaps choroidal arteriosclerosis, and sudden reduction of intraocular tension (e. g., in eyes with glaucoma) seem to be more important factors. Attempts to reduce the blood pressure preoperatively are, therefore, not indicated.

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<sup>2</sup> These needles are manufactured by Davis & Geck, Inc., New York.

<sup>3</sup> Hughes and Owens<sup>1</sup>. Owens, W. C., and Hughes, W. F., Jr. Intraocular Hemorrhage in Cataract Extraction, *Arch. Ophth.* **37**: 561 (May) 1947.

*Iridocyclitis*—The three chief causes of postoperative iridocyclitis are (1) retained lens material, (2) rupture of the hyaloid membrane of the vitreous and (3) low grade infection

1 *Iridocyclitis Due to Retained Lens Material* In the previously reported analysis of this series,<sup>1</sup> postoperative iridocyclitis was found to be closely related to the amount of residual lens capsule and cortex left in the eye at operation In 86 per cent of the 125 extracapsular extractions with iridocyclitis, the onset of the inflammation was within one month after the operation In 5 per cent the iridocyclitis appeared for the first time after a dissection, and in 2 per cent a previous iridocyclitis was reactivated by a subsequent dissection The clinical picture of postoperative iridocyclitis associated with retained lens material was nonspecific Inflammatory changes, such as thickening and vascularization of the iris, fine keratitic precipitates, formation of posterior synechiae and cyclitic membrane and, occasionally, exudation into the anterior chamber, were most pronounced in these cases with the greatest amount

*Importance of Retained Lenticular Material in Production of Ocular Changes in Postoperative Iridocyclitis*

Retained Lens Material	No of Cases	Keratitic Precipitates, %	Thickening and Vascularization of Iris, %	Synechiae and Cyclitic Membranes, %
None	16	18.8	25.0	6.3
Capsule only	52	21.8	31.2	9.2
Slight amount of cortex	19	21.0	42.0	5.3
Much cortex	24	29.2	58.3	25.0

of residual lens substances (table) Mutton fat keratitic precipitates were not ordinarily seen Corneal edema persisted in some cases In the few cases in which enucleation was done the nonspecific picture of subacute endophthalmitis was presented

In a compilation of data, it was found that in the majority of cases of iridocyclitis there developed a cutaneous sensitivity to lens protein The test for sensitization is performed by the intracutaneous injection of 0.1 cc of a 2 per cent solution of beef lens protein A reaction over 5 mm in diameter after twenty-four to forty-eight hours is considered positive, and reactions of 5 to 6 Gm are obtained in highly sensitive patients Positive reactions may develop as early as the tenth day after extracapsular extraction Desensitization was a valuable procedure in controlling this type of postoperative iridocyclitis, it is best carried out by Burky and Henton's method,<sup>4</sup> the principle being utilization of the synergistic antigenic activity of staphylococcus toxin to step up the weak antigenic activity of lens protein The technic of such

4 Burky, E. L., and Henton, H. C. Staphylococcus Toxin Combined with Lens Extract as a Desensitizing Agent in Individuals with a Cutaneous Sensitivity to Lens Extract, *Am J Ophth* 19:782, 1936

desensitization is as follows The dilution of staphylococcus toxin to which the patient shows a positive reaction (usually 1 100 to 1 10) is made up in a 2 per cent lens protein solution, and 0.1 cc. of this mixture is injected intracutaneously once or twice a week until no reaction is obtained In some cases of iridocyclitis and retained lens material in which cutaneous sensitivity to lens protein was demonstrated, the therapeutic effect of desensitization with the lens protein-staphylococcus toxin mixture was striking In other cases, the iridocyclitis cleared after surgical removal of the offending lens material

2 Iridocyclitis Following Rupture of the Hyaloid Membrane of the Vitreous Rupture of the hyaloid membrane at operation with presentation or loss of vitreous has been shown<sup>1</sup> to result in a relatively high incidence of postoperative iridocyclitis In such cases the eye usually remained congested, and the aqueous ray persisted with few changes in the iris for two to four weeks postoperatively

Rupture of the hyaloid face of the vitreous was often delayed several months after normal healing had occurred This was observed in a number of patients and may be more frequent than is commonly supposed The usual pattern of such late rupture was as follows Several weeks or months after operation iritic pain suddenly occurred The amount of pain was variable, sometimes being intense and sometimes being so slight that careful inquiry was needed to elicit its history Vision became blurred, and examination with the slit lamp usually revealed low grade iritis, a ruptured hyaloid membrane and some floating iris and ciliary pigment The iritis was usually of short duration and subsided with use of a mydriatic, such as scopolamine, with no residual damage This late complication usually occurred after round pupil intracapsular extractions and is probably due to pinching off the bleb of vitreous which frequently projects forward like a mushroom into the anterior chamber

3 Iridocyclitis Due to Low Grade Infection In some of the cases of postoperative iridocyclitis without retained lens material or rupture of the hyaloid membrane the inflammatory process may be due to a low grade infection However, it does not respond favorably to chemotherapy Nonspecific protein therapy in the form of intravenous injections of typhoid vaccine was the most effective method of treatment Local treatment consisted of mydriatics, hot compresses and short wave diathermy

*Secondary Glaucoma*—Glaucoma secondary to cataract extraction occurred in 87 cases in this series and was most often preceded by iridocyclitis Of less etiologic importance were nonreformation of the anterior chamber, capsular and cortical remains or loss of vitreous<sup>1</sup> In 12 of these 87 cases with secondary glaucoma normal tension was maintained over five years without operative intervention In the



remaining cases the intraocular pressure was uncontrolled by miotics, and operation was performed in 65

The choice of operation depends on the conditions in the anterior ocular segment which lead to the secondary rise of tension. In cases in which the angle is blocked by anterior synechiae or inflammatory debris, cyclodialysis is the operation of choice. McPherson<sup>5</sup> reported the results obtained in 52 such cases, finding that in 37 per cent cyclodialysis controlled the tension for at least one year, the majority of failures occurring within the first six months. Hemorrhage in the anterior chamber following cyclodialysis affected the prognosis unfavorably. Accordingly, pressure is applied over the site of the cyclodialysis immediately after rotation of the spatula, and any blood is washed out of the anterior chamber by means of the Randolph cyclodialysis instrument.<sup>6</sup> Since the success of cyclodialysis has been correlated by Barkan and his associates<sup>7</sup> with continued patency of the opening into the suprachoroidal space, the following measures are taken to promote this result: (1) selection of the site of operation in the upper quadrant if possible to avoid blocking of the angle should hemorrhage into the anterior chamber occur, (2) selection of a sector of the angle which is deepest and freest of peripheral anterior synechiae, and (3) continued use of miotics for at least several weeks after operation.

In a few cases of aphakic secondary glaucoma corneoscleral trephination was used. The results were comparable to those following cyclodialysis. This operation should probably be limited to eyes with a deep anterior chamber.

Chandler<sup>8</sup> has recently stressed the etiologic importance in cases of aphakic glaucoma of a block between the posterior and the anterior chamber. In these cases examination with the slit lamp reveals adhesions between the pupillary margins and the capsular remains or the intact hyaloid membrane. Because of this block the anterior chamber becomes shallow. To relieve the block, the communication between the posterior and the anterior chamber is reestablished either by a discission or by an iridectomy.

*Epithelial Downgrowth*—Intractable secondary glaucoma after cataract extraction may be caused by a downgrowth of epithelium into the anterior chamber. Only 1 enucleated eye in our series showed an epi-

5 McPherson, S. D., Jr. Cyclodialysis in the Treatment of Glaucoma, *Am J Ophth* **29** 848, 1946.

6 Randolph, M. E. A New Cyclodialysis Instrument, *Am J Ophth* **26** 187, 1943.

7 Barkan, O., Boyle, S. F., and Musler, S. Mode of Action of Cyclodialysis, *Am J Ophth* **19** 21, 1936.

8 Chandler, P. A. A Neglected Cause of Secondary Glaucoma in Eyes in Which the Lens Is Absent or Dislocated, *Arch Ophth* **37** 740 (June) 1947.

thelial downgrowth. This complication can be avoided by the use of a conjunctival flap of such size that its edges can be carefully sutured at an adequate distance from the corneal incision and by the use of a corneoscleral suture to insure firm closure of the corneal wound. In cases of persistent secondary glaucoma in which an epithelial downgrowth is suspected, irradiation has been used, but the effectiveness of this measure cannot be evaluated at present.

*Simple Detachment of the Retina*—Retinal detachment followed cataract extraction in 31 cases of this series. The incidence of this complication progressively rose with increasing amounts of vitreous lost at the time of extraction.<sup>1</sup> Bagley<sup>9</sup> studied in detail these and 27 additional cases of retinal detachment in aphakic patients operated on at the Wilmer Ophthalmological Institute. It was found that many retinal detachments in aphakic eyes occurred long after the cataract extraction, a history of predisposing trauma was not often obtained, and detection of retinal perforation was relatively uncommon. Such evidence suggests that loss of vitreous at the time of cataract extraction may initiate degenerative changes with the formation of traction bands, which subsequently pull off the retina. Retinal detachment followed extracapsular extractions as frequently as the intracapsular type, a fact which minimizes the importance of any supporting action which the posterior lens capsule-zonule diaphragm might be considered to have. Mechanical reattachment of the retina was achieved in 35 per cent of the cases in which one or more perforating diathermy operations were performed. Factors which contributed most to the failures were (1) duration of the detachment longer than two months before operation, (2) inability to find a retinal perforation before operation and (3) failure of the retina to fall back into position after the evacuation of subretinal fluid. In the last group of cases, injection of isotonic solution of sodium chloride into the vitreous or the anterior chamber to force the elevated retina back into place resulted in improvement in the operative results. In 18 cases in which two diathermy operations had failed, further attempts at reattachment were unsuccessful.

*Combined Detachment*—The patients in this series were not examined specifically to determine the incidence of combined detachment of choroid and retina after cataract extraction. However, combined detachments were usually found in eyes with a flat anterior chamber. O'Brien<sup>10</sup> pointed out that the combined detachment is probably the result of collapse of the chamber. Beginning subsidence of the combined detach-

9 Bagley, C. Retinal Detachments. A Comparison of the Etiology and Results of Treatment in Phakics and Aphakics, to be published.

10 O'Brien, C. S. Detachment of Choroid After Cataract Extraction. Clinical and Experimental Studies, with Report of Seventy-Five Cases, Arch Ophth 14 527 (Oct) 1935.

ment usually indicates an early reformation of the anterior chamber. If the anterior chamber reforms, a patient with combined detachment requires no special treatment and is discharged routinely from the hospital. All such combined detachments subside uneventfully, and there is no evidence that they predispose to simple detachment of the retina.

*Purulent Endophthalmitis*—Purulent endophthalmitis occurred in 21 cases of this series. It was usually detected on the first dressing one to four days after extraction. However, in 1 case endophthalmitis developed five weeks after the incomplete repair of a prolapsed iris and in another, eighteen months after the cataract extraction. In 2 cases purulent endophthalmitis followed capsulotomies performed months after the cataract extraction. In cases of most violent inflammation there were edema of the lids, edema and congestion of the conjunctiva, haziness of the cornea, exudate in the anterior chamber and blurred red reflex. Cultures of the secretion in the lower cul-de-sac usually revealed hemolytic *Staphylococcus aureus*, but in isolated cases *Staphylococcus albus*, streptococci, pneumococci, *Hemophilus influenzae* and *Escherichia coli* were found. In 4 cases the infection appeared to be primary in the anterior part of the vitreous; the cornea remained clear but vision was impaired by the formation of a cyclitic membrane. Occasionally the path of the infection could be traced down the corneoscleral suture.

The most likely sources of infection in these patients were (1) obstruction of the lacrimal ducts, with resulting low grade chronic dacryocystitis, (2) inadequately treated chronic conjunctivitis, (3) sudden onset of an acute infection of the upper respiratory tract a few days after operation, (4) superficial abscesses around corneoscleral sutures, infrequently with direct extension of infection along the suture tract into the anterior chamber, and (5) undetermined causes possibly a break in sterile technic at operation. Diabetes or the retention of lens material in the eye did not predispose to the development of purulent endophthalmitis. The following prophylactic measures have been employed for the last two and a half years, with the result that only 2 cases with purulent endophthalmitis have occurred in over 1200 extractions. 1 The lid margins, the conjunctiva and the lacrimal sacs are carefully examined before operation for signs of chronic infection. Routine preoperative cultures were taken for several years and then abandoned because it was found that significant chronic infection was manifest clinically.<sup>11</sup> The significance of pathogenic staphylococci on the lid margins and conjunctiva has been emphasized by Dunnington and Locatcher-Khorazo.<sup>12</sup> 2 Cultures are taken in suspicious cases, and any

11 Cooper, E. A Note on Preoperative Eye Cultures, *Am J Ophth* **16** 850, 1935.

12 Dunnington, J. H., and Locatcher-Khorazo, D. Value of Cultures Before Operation for Cataract, *Arch Ophth* **34** 215 (Sept.) 1945.

infection is eliminated by the local use of penicillin solution or ointment (1,000-2,500 Oxford units per gram) for a week or more before operation. At present penicillin solution is used locally at least three times during the twenty-four hours prior to operation. A 3.5 per cent tincture of iodine followed by alcohol is used for cleaning up the lids and brow. In a small series of cultures of material from the skin taken before and after operation, it was found that the iodine and alcohol were slightly better than a 1:200 tincture of nitromersol N.F. ("tincture metaphen, 1:200") and a 1:1,000 tincture of merthiolate (sodium ethylmercurithiosulfate). However, with all these substances, positive cultures were obtained from the skin of the lids after operation in over 25 per cent of cases, thus emphasizing the need to cover as much of the skin and brow as possible by careful draping. Rubber gloves are worn routinely. Sharp instruments are sterilized for forty minutes in 2 per cent saponated cresol solution U.S.P. Perhaps superior to this is the solution recommended by Post.<sup>13</sup> 3. Penicillin ointment is now used for dressing at the end of operation and daily thereafter, the first dressing being performed within twenty-four hours after operation. The frequent application of penicillin ointment occasionally results in sensitization to penicillin, producing edema and dermatitis of the lids. In a considerable proportion of cases in which operations were done during the period from 1939 to 1943, sulfadiazine or sulfamerazine was given orally as a prophylactic measure. From subsequent experience it appears probable that this additional measure is unnecessary.

Adequate intraocular penicillin levels are essential in the treatment of postoperative purulent endophthalmitis.<sup>14</sup> The highest levels of penicillin are obtained with the following methods: (a) subconjunctival injection of 2,500 Oxford units every four hours, (b) the application of cotton packs soaked in penicillin solution, 20,000 units per cubic centimeter, to the lower cul-de-sac every four hours, or (c) a single injection of 500 to 1,000 units into the anterior chamber or the vitreous.

The final vision following purulent endophthalmitis was poor in most cases. Prior to the days of sulfonamide therapy, all vision was lost in

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13. Post, M. H., and Moor, W. The Sterilization of Sharp Instruments by Chemical Solutions, *Am J Ophth* **25** 579, 1942.

14. von Sallmann, L. Penicillin and Sulfadiazine in Treatment of Experimental Intraocular Infection with *Pneumococcus*, *Arch Ophth* **30** 426 (Oct) 1943. Penetration of Penicillin into the Eye. Further Studies, *ibid* **34** 195 (Sept) 1945, Penicillin Therapy of Infections of the Vitreous, *ibid* **33** 455 (June) 1945. Struble, G. C., and Bellows, J. G. Studies on the Distribution of Penicillin in the Eye and Its Clinical Application, *J A M A* **125** 685 (July 8) 1944. Leopold, I. H. Intravitreal Penetration of Penicillin and Penicillin Therapy of Infections of Vitreous, *Arch Ophth* **33** 211 (March) 1945. Rycroft, B. W. Penicillin and the Control of Deep Intraocular Infection, *Brit J Ophth* **29** 57, 1945.

9 such cases, and enucleation was performed in 3. Of 12 patients treated systemically with sulfonamide compounds, 2 recovered 20/30 vision, 3 were able to count fingers, 3 lost all light perception, and 4 had enucleation or evisceration. One patient treated systemically with penicillin and sulfadiazine combined with subconjunctival injections of penicillin recovered 20/20 vision. A patient with an infection occurring on the tenth postoperative day failed to respond to systemic administration of sulfadiazine and injection of penicillin into the anterior chamber.

#### COMMENT

The present technic of cataract extraction used at the Wilmer Institute varies somewhat among individual cases, but in general it consists in the following routine. The pupil is dilated with 2 per cent homatropine hydrobromide. The orbicularis muscle of the lids is paralyzed by injection of procaine according to the Van Lint technic, or in some instances by the O'Brien block. Retrobulbar injection of 1.5 to 2.0 cc. of 2 per cent procaine hydrochloride and repeated instillations of 0.5 per cent tetracaine hydrochloride are used for local anesthesia. Occasionally general anesthesia induced with intravenous administration of sodium pentothal is used with apprehensive or uncooperative patients. The traction suture is inserted in the superior rectus muscle. A conjunctival flap about 3 to 4 mm. in size is dissected down to the limbus from 10 to 2 o'clock. A shelving horizontal groove is made halfway through the corneoscleral tissue at the base of the conjunctival flap from 11 to 1 o'clock, using a Lundsgaard knife. Two corneoscleral sutures of 000000 braided silk on an atraumatic needle<sup>2</sup> are inserted through these grooves according to the technic of McLean.<sup>15</sup> The corneal incision is usually made with a Graefe knife, but a keratome may be used. Should the suture be cut inadvertently, a complication which is surprisingly infrequent, the suture can easily be replaced. If necessary, the corneal incision can be enlarged with Castroviejo scissors. One peripheral iridotomy is made between the two sutures at 12 o'clock. The lens capsule is grasped at 6 o'clock, usually under the iris, with the Castroviejo or the Arruga intracapsular forceps. With counterpressure below, the lens is delivered by tumbling through the round pupil. The corneoscleral sutures are tied, the iris is repositioned if necessary, and the conjunctival flap is restored to its normal position with silk sutures. Physostigmine salicylate, 0.25 per cent solution, is instilled, followed by penicillin ointment. A binocular dressing with protective mask is applied. The first dressing is made the following day, and the patient is allowed out of bed within twenty-four to seventy-two hours after operation. The pupil is dilated with atropine on the

<sup>15</sup> McLean, J. M. A New Corneo-Scleral Suture, *Arch. Ophth.* **23**: 554 (March) 1940.

first or the second postoperative day. The corneoscleral sutures are removed on the eleventh day, and the patient is discharged the following morning.

#### SUMMARY

A study has been made of the causes, treatment and prognosis of complications following cataract extraction in 2,086 cases.

The complications related to insecure closure of the corneal wound, such as wide gaping with prolapse of vitreous or iris, delayed reformation of the anterior chamber and hemorrhage into the anterior chamber, are largely prevented by the use of two silk corneoscleral sutures. These complications are treated by excision of any vitreous, lens capsule or iris tissue caught in the lips of the wound, and closure by means of a conjunctival flap or additional corneoscleral sutures. If the anterior chamber does not show signs of reforming within seven to ten days, air is injected into the anterior chamber.

Postoperative iridocyclitis occurs most frequently in patients with retained lens cortex. Many of these patients acquire a hypersensitivity to the retained lens cortex and respond well to intracutaneous desensitization and operative removal of the lens material. Iridocyclitis may also follow loss of vitreous at operation or late rupture of the hyaloid membrane.

Secondary glaucoma most frequently follows postoperative iridocyclitis. In only a small fraction of cases is the tension satisfactorily controlled with miotics, in the majority operative intervention being required.

Postoperative simple detachment of the retina is usually associated with loss of a significant amount of vitreous at the time of operation. The results after perforating diathermy operations were poor if more than two months had elapsed after the onset of the detachment or if the retina failed to fall back satisfactorily after withdrawal of subretinal fluid. In cases of the latter, the injection of isotonic solution of sodium chloride into the anterior chamber to force the retina back into position greatly improved the prognosis.

Suggestions are presented for the prevention and treatment of postoperative purulent endophthalmitis.

#### ABSTRACT OF DISCUSSION

DR. M. HAYWARD POST, St. Louis. In the past few years certain factors have entered the technic of cataract extraction which have resulted in pronounced changes in the relative importance of the various complications following this type of surgical intervention. The introduction of corneoscleral sutures is undoubtedly the greatest single advance in the surgical technic during this time. I have been able to achieve excellent results in several cases, in which without this safeguard the eyes would have suffered severe loss of vitreous, and probably ultimate destruction.

I prefer to use one McLean suture. The advantage of two or more is readily understood and in the hands of experts probably justifies their use, but the complications referred to by the authors undoubtedly have to be reckoned with. I am surprised at the emphasis placed on the difficulties of the removal of these stitches, for except where the suture has been a little too deeply placed, resulting in leakage of the aqueous, they appear to be well tolerated for twelve or fourteen days, by which time their removal is much facilitated. Care should be taken to place them as superficially as possible. It is surprising what a small bite of either sclera or cornea is adequate. I have never seen a suture so placed cut out after being successfully tied, until at least ten days had passed. Use of a surgeon's knot prevents slipping and the danger of buckling of the wound. My colleagues and I have experienced comparatively few cases of phakoanaphylactic reaction among 214 extracapsular extractions performed since Oct. 1, 1944. In 1 of these, a case of my own, in which the patient was nervous and had a cardiac lesion which prohibited the use of pentothal sodium anesthesia, vitreous was expelled after the capsulotomy, so that a large part of the cortex could not be delivered. Some years ago, Dr. Burky let me have a quantity of lens extract to be used in the diagnosis and treatment of this condition, but unfortunately, the number of such cases at that time was insufficient to make possible any definite conclusions. The present method of Dr. Burky and Dr. Henton appears to be a considerable advance in the elimination of this troublesome complication. Probably the next most important factor in changing the postoperative picture is the remarkable reduction in the frequency of infection which has followed a better appreciation of the sources from which it arises. The almost universal wearing of rubber gloves, the use of penicillin and the sulfonamide compounds for several days before operation and the instillation of penicillin drops or ointment at the close of operation have undoubtedly played a considerable part in this fortunate result. In our clinic, the use of the sterilizing solution recommended by myself and, more recently, since Oct. 1, 1944, the care of dust-borne infection by dipping the tips of the instruments, such as Graefe knives, keratomes and forceps into a 1:3,000 solution of benzalkonium chloride ("zepliran chloride") immediately before use, have resulted in the almost entire elimination of septic intraocular infection in 573 consecutive cataract extractions and 263 intraocular operations for glaucoma, postcataract membranes, etc. But in 2 cases in which the procedure was omitted infections did occur after a cataract operation in 1 case and after incision of the sclera during an operation for detachment of the retina in another. The figures quoted in the authors' paper are also much smaller than was considered the irreducible minimum a few years ago. It is obvious that such a reduction in the likelihood of this dreaded complication, in conjunction with the corneoscleral suture, has permitted far greater manipulation of the eye than would previously have been considered advisable. A more meticulous toilet of the wound is possible. The iris can be carefully replaced and the tags of capsule and vitreous removed with certainty from the lips of the wound. Far greater effort, also, can be made to remove all cortex by expression and irrigation, so that the incidence of phakoanaphylactic reaction can be kept at a minimum. I am in thorough agreement with the authors, Dr. Derrick Vail and many others.

that intraocular hemorrhage occurring about the fifth day, or later, arises from the lips of the wound, and that the best safeguard against this troublesome sequel lies in placing the section as far out in the cornea as is compatible with preserving the conjunctival flap. Since I have been observing this rule, my own cases have been comparatively free from this complication.

We have had no experience with the late injection of air into the anterior chamber in order to break up adhesions between the root of the iris and the corneal angle. The procedure sounds logical, provided breaking down of the wound can be avoided. It is recognized that air bubbles introduced at the time of operation are well tolerated, indeed, several of us at the McMillan Hospital have purposely permitted such bubbles to remain in the anterior chamber at the close of operation.

DR. FREDERICK ALLISON DAVIS, Madison, Wis. The authors' main thesis is based on the reduction in number and seriousness of complications which has followed certain changes in technic introduced at the Wilmer Institute during the period covered by this survey. They maintain that the general systemic condition of the patient has played a less important role than the operative technic in these results. They submit data which support the conclusion that the intracapsular method of extraction, with a round pupil, and closure of the deep wound with two corneoscleral sutures of the McLean type have been followed by the smallest number of postoperative complications and the best final results.

Unquestionably the technic employed in cataract extraction is a determining factor in a certain proportion of cases, but in my opinion the skill of the operator and the general physical status of the patient play a most important role in the final outcome. The authors have shown the favorable influence of intracapsular delivery of the lens and of two corneoscleral sutures. The incidence of incomplete closure of the wound, prolapse of iris, hemorrhage in the anterior chamber and secondary glaucoma was definitely reduced when this technic was employed. The marked reduction in postoperative iridocyclitis is noteworthy and offers a potent argument for intracapsular extraction of the lens. Since preservation of the round pupil limits loss of vitreous at operation, the complications that frequently follow this accident are thereby reduced. The authors have shown that with the use of two deep sutures the round pupil operation can now be undertaken with much greater assurance of success, since prolapse of the iris can be reduced to a minimum. My own experience has fully confirmed this observation. The value of pre-placed deep sutures in limiting the amount of vitreous lost when it presents cannot be too strongly emphasized. The accurate apposition of the wound also prevents later spreading and further loss, and thereby reduces the high degree of astigmatism which so often follows this complication. The authors record delayed reformation and late loss of the chamber in 3.2 per cent of the cases. Here the favorable influence of deep suturing apparently was lost in part, since more than half these complications attended or followed removal of the sutures. Likewise, hemorrhage into the anterior chamber followed removal of the sutures in 3.6 per cent of 1,030 cases in which deep suturing was used. It seems to be a serious indictment of sutures so deeply placed that loss of the chamber and bleeding occur when they are removed. It is questionable whether the final excellent results here reported can be maintained.



unless the hazard incident to the removal of the sutures can be eliminated. In my experience, a smaller and more superficial bite of the needle and the use of absorbable surgical gut sutures have prevented accidents of this type. My colleagues and I do not remove deep silk sutures before the twelfth postoperative day. If the eye is irritated or the patient uncooperative, akinesia will be found helpful in avoiding these accidents.

The authors have shown that iridocyclitis and a flat anterior chamber were the chief contributing factors in the production of secondary glaucoma. Intracapsular delivery of the lens and the use of deep sutures appear to have been mainly responsible for reducing the number of cases of this complication. In our experience, intracapsular delivery of the lens, with conjunctival sutures only, has reduced secondary glaucoma to a minimum. However, in a recent series of 350 extractions, we have had an increase in this complication following the use of the keratome-scissors method of incision combined with deep suturing. I am inclined to believe that the increase in the number and variety of complications has been chiefly due to the keratome-scissors incision rather than to the added trauma incident to the placing of deep sutures.

It would prove helpful if the authors gave us a more precise description of the technic which they now use when opening the globe.

Retinal detachment, in our experience, is infrequent after cataract extraction. In a study of 104 cases of retinal detachment at the University of Wisconsin General Hospital now in preparation by my associate, Dr. Peter A. Duehr, it is noted that 16 cases developed in a series of 1,750 extractions. Loss of vitreous was a contributing factor in but 3 cases, in 2 of which liquid vitreous followed the incision. In 13 cases vitreous was not lost at operation. Detachment occurred over periods varying from two weeks to thirteen years after operation. In 12 cases retinal detachment followed intracapsular and in 3 cases extracapsular operations, and in 1 case it developed thirteen years after needling for congenital cataract.

The increase in postoperative infections, formerly reported, which the authors attributed to deep sutures, has been materially reduced by the use of certain prophylactic measures, chief of which appears to be the local use of penicillin before operation. For more than a year we have been using penicillin ointment locally, and in many cases it has been effective in clearing the conjunctiva of bacteria and pus cells, as revealed by smears.

In spite of the excellence of the results obtained by some changes in technic of cataract extraction in recent years, one cannot but reflect on the increasing number and complexity of procedures now advanced by various surgeons. Certainly, the time consumed in placing sutures and the variety of methods now in practice for opening the globe have transformed the operation for cataract into a formidable and lengthy procedure.

1. DR. VICTOR CLOUGH RAMBO, Mungeli, India. Central Provinces, India, has been my working place for twenty-two years. Mungeli is 34 miles (54 kilometers) from the railroad. Persons with sick eyes have come to us there in large numbers. Last year our hospital did 2,327 operations on the eye, 1,078 of which were for the removal of cataract.

Except for the financial backing, there is no reason that the year after next we could not do 10,000 operations for cataract in and around our hospital. The blind with cataract are there. It is possible that well chosen teams sent from this country, properly financed, and knitted in with the All-India Ophthalmological Society and the missions, which are so capable in bringing blind persons into camps for ophthalmic surgery, might be the means of giving further thousands the sight for which they yearn. Chandra Kartik Dutt (Lever Action Operation for Intracapsular Extraction of Cataract, *ARCH OPHTH* 18:897 [Dec] 1937) stated that though 100,000 operations for cataract are performed in India each year there are 500,000 persons in India who are blind with operable cataracts. This means that in India there are approximately 1,000,000 eyes with cataracts which the science of ophthalmology does not reach. Brigadier General Hance, now director of the India Medical Service, said to me that the number of people blind with cataract in India was closer to 1,000,000 than to the 500,000 mentioned by Dr. Dutt. In a survey of seven villages around Mungeli my colleagues and I found 1 out of 100 of the total population—men, women and children—blind with operable cataracts.

In doing such a large amount of surgical work, and in doing it almost immediately after the patients come in, we have had to adopt a strict technic. If any one came out to work with us, we should insist on certain procedures that we have found to be important. In using the speculum, we should insist that in being inserted it touch nothing but conjunctiva. It is a technical surgical error to allow the speculum to be touched by the skin beyond the edges of the lids. A sterile applicator will open the lids so that the speculum can be put in. Fingers are not used. We should insist that an instrument, an iris repositor, put into the anterior chamber and then brought out, should not be used in the eye again until it had been resterilized. So that there may be no delay, we keep duplicate instruments ready for immediate use. We have not been using gloves during operation. When we use no sutures, our hands touch no part of any instrument that touches the eye. Even gloved fingers that touch the skin of the lid cannot be considered sterile any longer. However, the statistics presented are thought provoking. We may be using gloves soon—if we can afford the extra cost and if the skill and speed lost in using gloves is not too serious a handicap. The paper by Dr. Hughes and Dr. Owens is a most helpful one. I am happy over the progress that has been made in dealing with the problem of infections and other complications of cataract extraction, which this report has brought out. Dr. Hughes and Dr. Owens have done ophthalmology a great service by presenting the routines followed which have allowed them to present this fine statistical report.

We remove 19 out of 20 cataracts through the round pupil with a tiny peripheral iridectomy. We test each pupil with homatropine before operation. If it does not dilate with homatropine, we realize that something is wrong, and we are ready to perform complete iridectomy, doing the combined extraction. But most pupils will dilate. For the Indian we find it definitely better to have a round pupil. A large pupil to face the glare of the Indian sun is not desirable. But we do not "hang ourselves on a round pupil," as one of my New York teachers recently said, and we are ready to do a combined extraction whenever necessary.

Most of our cataracts, 5 out of 7, come out intracapsularly. We use the Arruga forceps. Occasionally a cataract is found the capsule and the zonule of which will not break. This presents a real problem, demanding judgment. We must use "nonviolence" and when we find such a problem we do a capsulotomy and are glad to get out of it the best way we can, by doing an iridectomy if necessary and expressing the lens. It is in cataract surgery that the ophthalmologist has some of the most thrilling experiences. Even though he may do the cataract operation twenty-five times a day, with every cataract that is removed there is a relief and joy scarcely approached by the joy of any other procedure.

DR WALTER B LANCASTER, Boston. One of the discussers mentioned the great variety of sutures used, and one referred to them as though one suture were the same as another. This is far from the case. Some sutures do more harm than good. Unless the suture is perfectly appositional, it prevents the lips of the wound from fitting together and does harm. To be perfectly appositional, it must be inserted in some such way as the McLean method, which seems to me to be the best. That method maintains perfect apposition, and it is rare not to have the anterior chamber reestablished at the first dressing.

The authors did not mention the matter of iridectomy. It seems to me that by far the most ideal operation demands the round pupil, and this type of extraction is easy if one uses the proper technic. However, to be sure to avoid prolapse and anterior synechia, iridectomy is needed, and that should be done in the form of a peripheral buttonhole. Wilding, of Duluth, Minn., has demonstrated how it should be done and I can bear him out as a result of my experience. The sutures should be at 11 and 1 o'clock. That leaves spaces between 9 and 11, 11 and 1, and 1 and 3 o'clock, where iris can present and become entangled. Therefore I do an iridectomy between 9 and 11 o'clock, or at 10 o'clock, and between 1 and 3, or at 2 o'clock. These two small buttonholes are formed before the lens is extracted. The pupil has been dilated, not with atropine but with paredrine hydrobromide (para-hydroxy-alpha-methylphenylethylamine hydrobromide) or ethyl aminobenzoate, aided with cocaine and epinephrine, so that the pupil is well dilated. The lens is extracted through the dilated pupil. The two sutures are tied, or perhaps only one tied, and then a third iridectomy is done at 12 o'clock. If that iridectomy is done before the extraction, it is quite possible to have the lens catch in the opening. Therefore, it is better to do the last iridectomy after the lens is extracted and when one or both sutures are tied.

DR WILLIAM F HUGHES JR, Chicago. It is encouraging to hear that further experiences with these newer technics in various parts of the country are found to eliminate many of the serious complications resulting from insecure closure of the wound and retention of lens material. With use of two corneoscleral sutures and a relatively shallow section toward the corneal side, the anterior chamber is practically always formed again after twenty-four hours. The incidence of prolapse of the iris and the vitreous is much reduced, and spontaneous hemorrhages in the anterior chamber have become unusual. As Dr Davis has pointed out, however, the use of corneoscleral sutures is not an unmixed bless-

ing, but we believe that the difficulties associated with their use are of a less serious nature and can largely be prevented if special precautions are taken in the placement and removal of the sutures. These precautions correspond in almost every exact detail with those which Dr Post has enumerated. They include more care in the prevention of infection. The two McLean silk corneoscleral sutures are inserted by first dissecting a conjunctival flap as far down on to the limbus as possible. A notch, slanting about 45 degrees toward the corneal side, is then made about halfway through the cornea at the base of the conjunctival flap. The corneoscleral sutures are then inserted at 11 and at 1 o'clock, first up through the base of the conjunctival flap, then back, with relatively long bites in the scleral and corneal lips of the notch. The sutures should be left in place at least ten or twelve days, and preferably two or three weeks, before they are removed, so that the wound is well healed and will not rupture or result in a hemorrhage in the anterior chamber. The retention of a round pupil is accomplished with one peripheral iridotomy at 12 o'clock between the two corneoscleral sutures. Preservation of a round pupil is probably of less importance, although it gives a beautiful cosmetic result, reduces glare and in all probability reduces the incidence of loss of vitreous at operation.

We feel strongly that postoperative iridocyclitis, particularly that following retention of lens material, is one of the most serious complications of cataract extraction, frequently leading to secondary glaucoma or cyclitic membranes. The possibility of sensitivity to lens protein should be investigated in these cases, and if necessary, desensitization should be performed with lens protein-Staphylococcus toxin mixture, combined with operative removal of any residual lens cortex.

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## MACULAR HOLE WITH EXTENSIVE PERIPHERAL DETACHMENT OF RETINA

ANDREW RADOS, M D

NEWARK, N J

TWO AUTHORS described hole formation in the macular area of the retina independently of each other at about the same time—Haab,<sup>1</sup> in Switzerland, and Ogilvie,<sup>2</sup> in England. In this connection, it is interesting to note that in the same number of the *Zeitschrift*<sup>1</sup> in which the work of Haab appeared Kuhnt<sup>3</sup> described the same entity, he did not designate it as hole formation, but called attention to peculiar macular changes in the retina (retinitis atrophicans sive rareficans centralis). This difference in definition may be responsible for Kuhnt's observation frequently going unnoticed, hole formation in the macula remaining linked to the names of Haab and Ogilvie. Haab's review of the previous literature revealed 3 cases (Hoffmann,<sup>4</sup> Hartridge<sup>5</sup> and Lawford<sup>6</sup>) with similar pathologic changes which probably fitted into the group of his cases, all had in common a traumatic origin and to a greater or less degree, the characteristics of hole formation.

Haab had already recognized that the clinical picture in his 12 cases represented hole formation in the macula. The history revealed a traumatic origin in only 9 of his series, in the other 3 instances there was no history of blunt injury representing concussion and therefore, by exclusion, the spontaneous origin was at once evident. The cumulative results of observation in the following years proved that the hole formation may occur spontaneously, without any trauma, nevertheless, considering that the greater majority of his cases had a traumatic basis, Haab left undecided the nontraumatic origin of hole formation.

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From the Ophthalmic Department of the Beth Israel Hospital

1 Haab, O. Die traumatische Durchlochung der Macula, *Ztschr f Augenh* **3** 113, 1900

2 Ogilvie, F. M. "Holes at the Macula" A Result of Injury to the Eye by Concussion, *Ophth Rev* **19** 232, 1900

3 Kuhnt, H. Ueber eine eigentumliche Veranderung der Netzhaut in Macula (Retinitis atrophicans sive rareficans centralis), *Ztschr f Augenh* **3** 103, 1900

4 Hoffmann, F. W. Embolie eines Astes der Arteria centralis retinae mit hämorrhagischem Infarkte, *Klin Monatsbl f Augenh* **23** 24, 1885

5 Hartridge, G. Peculiar Appearance of the Macula, *Tr Ophth Soc U Kingdom* **9** 144, 1889

6 Lawford, J. B. Peculiar Changes in the Macular Region, Possibly Traumatic in Origin, *Tr Ophth Soc U Kingdom* **13** 76, 1893

According to Haab, the hole is about one-half the diameter of the disk, red and round, the differentiation from the adjoining retina varies, depending on the cloudiness of the latter. The retina surrounding the red disk frequently exhibits delicate gray dots or lines. Against the red background of the hole are small, more or less numerous white or yellowish dots or patches with intermingled brownish spots. The hole formation in the red spot is proved by parallax and the slight difference in refraction between the margin and the bottom in a manner similar to that in which the depth of cupping of the disk is measured. The relatively larger size of the red spot, together with the sharp, round margin, differentiates it from the red spot visible in cases of occlusion of the central artery. The bright red color of the spot depends on the direct view of the underlying, exposed choroid, with the intact layer of pigment epithelium, ophthalmoscopically, the red color is similar to that familiar in fresh retinal tears and in holes of the detached retina. The dots at the bottom of the hole represent remnants of retinal tissue and, according to their number and shape, show a wide range of variation in the course of development in the same case, or possibly they may be accumulations of wandering cells. Central visual acuity is always greatly diminished, and a large central scotoma is noted in all cases. The typical circular form may change to oval through shrinking of the adjoining parts of the retina as a result either of fibrinous deposits on the surface or of degeneration of connective tissue. The hole itself is framed with a narrow gray ring of cloudy retina, the appearance recalling the cloudy area in cases of arterial occlusion, but the cloudiness is always of a much slighter degree. Haab noted spontaneous hole formation due to necrosis associated in a flat detachment of the central portion of the retina.

Ogilvie observed 15 cases of macular hole. He described the lesion as a deep punctured hole, generally circular or oval, as though the macula had been trephined out, he stated that the diameter is about one-half or one-third that of the optic disk. The area is depressed and bright red, with clearcut edges, the depth of the hole averaging 1.5 D. He compared the lesion to a hole broken in thin ice. The floor of the red area is peppered with fine pigment dots. Remnants of the retina remain as granules on the exposed choroid, whereas the edges and other portions curl up and are hidden behind the edges of the hole. The surrounding 'pleats and folds represent edema of the retina and accordingly disappear after a time. Anatomic evidence that the hole formation is due to force applied by a blunt instrument is given by the fact that the foveola itself is the thinnest part (0.1 mm.) of the retina and the edges are the thickest (0.49 to 0.50 mm.) and the structures sharply change from thickest to thinnest as one passes from the edges to the central, thin depression. The 15 cases of hole

formation observed by Ogilvie formed two distinct groups, cases with and cases without retinal detachment. In the cases the detachment differs from the usual type, the retina remaining transparent and the detachment showing no tendency to increase, even after the lapse of considerable time, the detachment is usually shallow and extends over a large area. Degenerative changes, frequent with other types of old detachments, do not develop. Ogilvie's clinical description is so complete that almost nothing is omitted. The conclusion, however, that the hole formation represents only a traumatic lesion, and that no other cause may contribute to it, cannot be maintained in view of the present knowledge concerning spontaneous, nontraumatic hole formation.

Kuhnt's study was based on 4 cases, 1 of traumatic and 3 of spontaneous origin, his description of the ophthalmoscopic picture is similar to that of Haab and Ogilvie. The shade of the red spot showed slight variation, corresponding to the pigmentation of the choroid and pigment epithelium, but in all cases the color appeared to be more saturated than that of the fundus. The depth of the depression measured 0.75 to  $-1.0$  D. The granular appearance of the floor depended on the presence of vascular loops in the choriocapillaris and the peculiarities of the epithelial layer. Hole formation of traumatic origin is produced through softening of the avascular central portion of the retina, the holes of spontaneous origin result from retinitis of the posterior pole, leading to atrophy of the central portion of the retina. Kuhnt emphasized that the changes included only the retina, whereas the choroid presented no visible pathologic signs, even after years, a characteristic which differentiates hole formation in the macula from the senile circulatory changes, the latter being known to involve the choroid, if not all layers, at least the choriocapillaris and the layer of small vessels.

The entire question of hole formation in the macula was given a scholarly and thorough consideration by Duke-Elder,<sup>7</sup> who quoted H. Knapp and Noyes as the first observers of isolated cases of this lesion. The most common cause is trauma, such as contusion injuries of the globe or retention of foreign bodies. Ogilvie assumed a contrecoup mechanism, which accounts for the cases in which hole formation occurs immediately after a severe blow to the anterior segment but is not adequate to explain the cases in which the hole results from a laterally directed blow or considerable time elapses between injury and hole formation. In cases of the last type the mechanism consists in cystic degeneration of the avascular central area with rupture of the cystic walls. In the cases of nontraumatic origin the etiologic agent is either degenerative (senile or cardiovascular) or toxic (toxins of the vitreous derived from an inflammatory process in the anterior segment).

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<sup>7</sup> Duke-Elder, S. W. *Text-Book of Ophthalmology*, St. Louis, C. V. Mosby Company, 1941, vol. 3.

Macular hole is not invariably associated with detachment of the retina, thus, in a series of 23 cases Middleton found only 1 case of detachment. Duke-Elder stressed that peripheral retinal holes are usually associated with large and extensive detachments, the macular holes causing only limited and nonprogressive retinal separation.

Discovery of peripheral holes in cases of detached retina preceded that of the macular holes. Peripheral holes were noted by Coccus (1853) and von Graefe (1863), and later de Wecker drew attention to their striking frequency of association with detachment in myopic eyes (1870). De Wecker, Martin and le Lucca employed ignipuncture as a therapeutic measure, and Scholer expressed the belief that closure of the retinal rent is the logical remedy for the condition. Still, the isolated cases of closure of the hole remained unrecognized and unappreciated. Finally, the dramatic therapeutic results of Gonin focused attention on the importance of hole formation in the pathology of retinal detachment and led subsequently to appreciation of the fact that closure of the hole or tear is of extreme importance. Gonin's work centered attention on search for the holes, and their presence was noted in ever increasing numbers. Additional data were accumulated on the frequency of retinal dehiscences in cases of peripheral detachment and the relative infrequency of detachment with macular holes, the latter circumstance lacks a proper explanation. Vogt<sup>8</sup> mentioned 3 cases of macular hole with detachment, Arruga,<sup>9</sup> 6 in a series of 132 cases of detachment, Meisner,<sup>10</sup> 5 in a series of 90 (3 without peripheral holes), and Schmidt,<sup>11</sup> 9 in a series of 200 cases, Stein<sup>12</sup> referred to 6 cases, and Prevec,<sup>13</sup> and similarly Weve,<sup>14</sup> reported 4 cases.

Vogt's first case was that of a woman aged 25, with myopia of 28 D. The macular hole was very small, with the cover toward the disk, the

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8 Vogt, A. Operative Therapie und die Pathogenese der Netzhautablosung, Stuttgart, F. Enke, 1936, 6 Monate alte Netzhautablosung, entstanden durch isolierten Maculaloch, Verschluss des Loches durch Katholysen- und Diethermiesichelung, *Klin Monatsbl f Augenh* **100** 130, 1938.

9 Arruga, H. The Detachment of the Retina, translated by R. Castroviejo, New York, B. Westermann, 1936.

10 Meisner, W. Das Maculaloch bei der Amotio retinae, *Klin Monatsbl f Augenh* **98** 379, 1937, Zum Vorkommen und zur Entstehung der Netzhautablosung, *ibid* **97**.289, 1936.

11 Schmidt, R. Ueber Lochbildung in der Netzhautmitte, *Klin Monatsbl f Augenh* **102** 788, 1939.

12 Stein, R. Zur operativen Therapie der Netzhautablosungen mit macularen oder maculanahen Netzhautlochern, *Klin Monatsbl f Augenh* **98** 395 and 402, 1937.

13 Prevec, S. Ueber einige langer beobachtete Falle von centralen Netzhautablosungen, *Klin Monatsbl f Augenh* **97**.289, 1936.

14 Weve, H. Die Heilung durch Fovealocher verursachter Netzhautablosung mittels Diathermie, *Arch f Augenh* **109**·534, 1936.



width being equal to that of a central vein (the picture shows the hole to be pinhead in size, as compared with the disk), the detachment was extensive, with many folds, sacklike in the temporal region and beginning at and including the macula, no tear was noted in the periphery. In his second case, that of a woman aged 62, there was a refractive error of +20 D, with a horizontal oval hole in the macula, the greatest diameter corresponding to one-half that of the disk. The hole was the result of cystic degeneration of long standing, the adjoining retina showed a flat detachment. In both cases catholysis was employed. In the first case two sittings resulted in good vision, in the second case twenty catholytic punctures were employed. After the operation vision was improved, the hole was still visible, only the margins were turned toward the choroid, with scarification of the adjoining retina and one pigment patch between the macula and the disk. Vogt described another case of retinal hole with detachment in which operation was not performed, both eyes showed excessive myopia, and in the left eye an extremely small punctate hole was observed, with extensive detachment of the temporal part of the retina. In the early period the detachment was flat and central, later, extension into the periphery with folding developed, without the presence of a peripheral tear.

In Schmidt's series, of 14 cases of macular hole, 6 were due to trauma. In 4 cases the eyes were myopic, in 3, hypermetropic, and in 7, emmetropic. Of the 8 cases of spontaneous origin choroiditis was present in 2, periphlebitis in 2 and high myopia in 3, in 1 case there were macular hole with cystic changes in the surrounding retina and macular degeneration in the fellow eye. Of 14 cases of macular hole, 5 presented no detachment, 4, a small ring-shaped detachment of the area around the hole but not extending over the fovea, and 5, extensive detachment (in 1 case almost total detachment followed unsuccessful operative intervention). In the majority of cases perimacular detachment proved to be stationary, and not progressive, in 1 (case 9) spontaneous reattachment of the perimacular separation even occurred, in the 4 cases of macular hole without detachment the process did not develop further in the course of longer observation.

In the 4 cases reported by Prevec the eyes were hypermetropic, and therefore the macular holes were classified on the basis of senile degeneration. In 1 case there was cystic degeneration of the macula of the sound eye, in his second case the hole was the direct result of previous macular degeneration. In 2 cases macular hole developed in the wake of cystic degeneration with central detachment without the presence of any traction on the part of the vitreous, which may be an additional factor in the production of peripheral tears and detachments. In the first case, that of a woman aged 68, a macular hole was surrounded by cystic degeneration, the hole was round and of one-third disk diam-

eter, and in red-free light a yellow coloration of the peripheral parts was discernible. The hole was surrounded by a flat detachment, of horizontal oval form and measuring 3 or 4 disk diameters. Six punctures with a cathode needle was followed by a complete reattachment, as observed after five months. The second case was that of a man aged 63, with posterior detachment of the vitreous, cystic degeneration of the macula and three large central cysts with a wreath of small ones, two weeks later a fresh detachment, of 4 disk diameters, appeared at the posterior pole. Of the three central cysts, two lost their anterior limiting walls, resulting in a double hole in a cystic floor, red-free light revealed the presence of holes. In the further course of development, the wall of the third cyst disappeared; the resulting hole was almost circular, and the detachment simultaneously expanded. Later observation showed that the circular outline of the hole changed first to a vertical oval, the later shrinking was responsible for scalloping of the margins, with further expansion of the retinal separation. The hole gradually diminished in size, to be followed by complete spontaneous closure, folding and, finally, complete spontaneous reattachment of the retina. In the third case, that of a man aged 72, a cataract in the left eye had been extracted one year previously, there was a round macular hole measuring  $\frac{1}{3}$  disk diameter (senile macular degeneration of the other eye) with a flat circular detachment of 3 disk diameters. At the end of eight months the hole had become decidedly larger and the detachment remained unchanged. In his fourth case, that of a woman aged 77, a small cyst without hole formation was first noted in one eye and a slight degree of macular degeneration with dislocation of pigment in the other eye. Examination four weeks later disclosed a small round hole in the first eye with fresh detachment of a few disk diameters at the posterior pole, both disappeared spontaneously within six months, leaving visible only dislocation of pigment in the area.

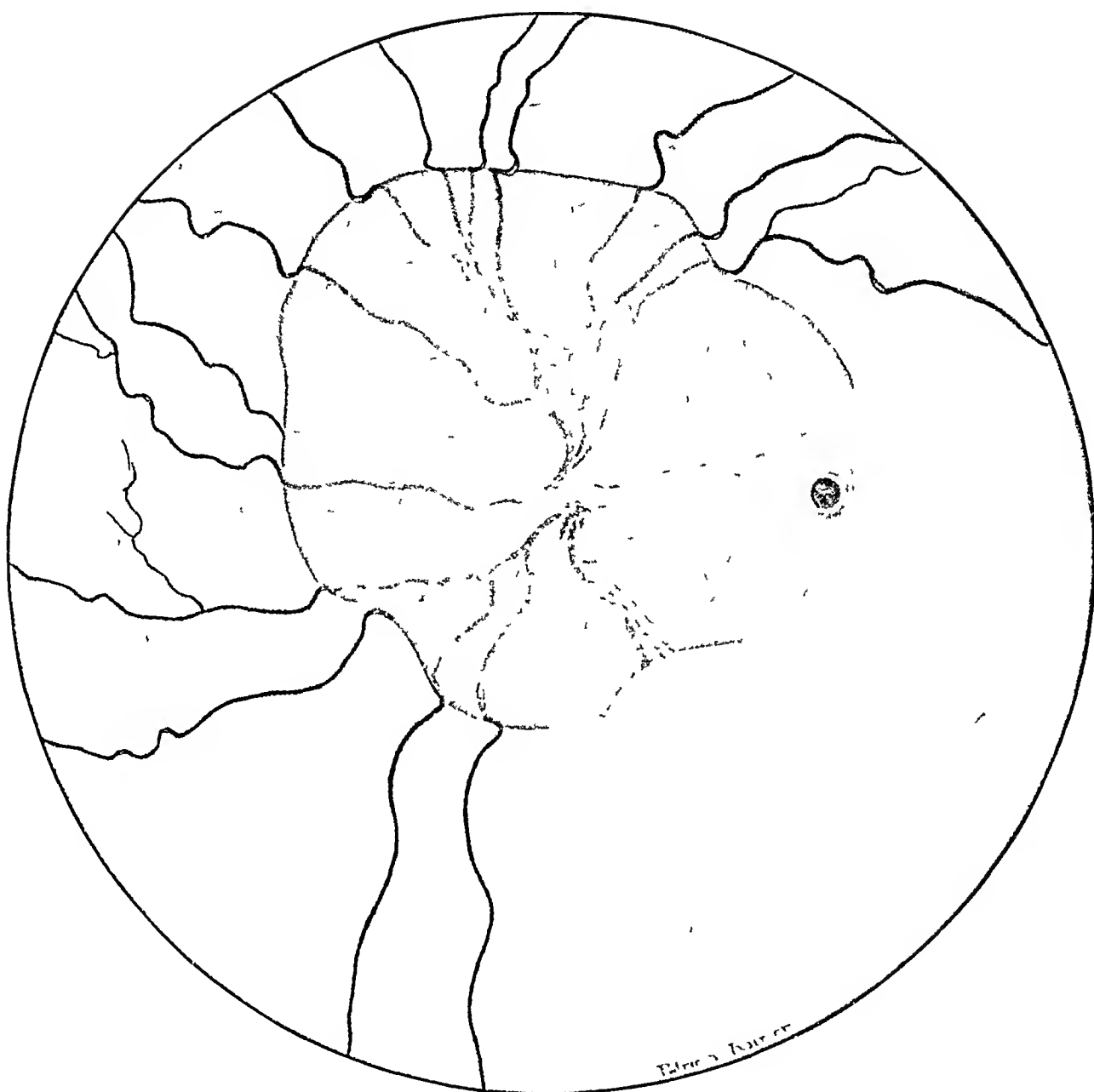
In the 3 cases of Weve the characteristic features were high myopia and extremely small holes in the macular area (in the first case a small triangular hole, in the second, punctate holes, and in the third, a very small round hole) with extensive detachment of the retina. In the first case the detachment was almost total except for a small sector in the upper nasal portion, in the second case there were a rather flat separation in the upper part and an extensive, bulging, cystlike detachment in the lower part, and in the third case, flat but extensive detachments were present in the lower and temporal upper portions.

#### REPORT OF A CASE

Recently, I observed a woman aged 46, the eyeground of whose left eye is reproduced in the figure. The patient had been examined for the first time ten years previously, when she had a refractive error of  $-4.0$  D sph  $\subset -0.50$  D cyl,

axis 180 in the right eye and  $-4.50$  D in the left eye. Vision in the right eye had become poor three months prior to the first examination, and the vitreous exhibited a large amount of dustlike opacities, which in transillumination appeared partly dark, and partly as bright, shiny spots. The vision was reduced to counting fingers at a distance of 0.5 meter, and was not improved with appropriate glasses. There was extensive detachment in the temporal lower part of the retina, the area of maximum separation being directed downward and measuring  $+8.0$  D. The detachment showed the typical folding. In the direction of 6 o'clock 3 disk diameters distant from the optic disk, one heart-shaped and one pinhead-sized retinal hole were discernible. In the lower temporal region there was cystic degeneration of the retina, with splitting and numerous punctate holes. The detachment reached the ora serrata, which was widely torn off. The penetrating diathermic punctures resulted in closure of the holes and complete reattachment of the retina and vision improved to 15/30. With proper correction, the left eye had normal vision, and there were no pathologic changes in the fundus. Almost ten years later the patient again presented herself. The condition of the right eye was unchanged; the field of vision showed slight peripheral indentation. Vision in the formerly normal left eye was limited to hand movements, the vitreous showed dustlike opacities, with a brownish emulsion visible with the slit lamp. The ophthalmoscopic appearance of the retina is well portrayed in the figure. In the macula there was a large, round, punched-out hole, one-third the size of the disk. The margins of the hole were apparently in contact with the underlying structures, the retina around the hole itself was not detached, but an almost circular detachment reached the periphery in every direction. The amount of detachment varied, but in some places amounted to  $+12.0$  D. The detached retina showed the typical grayish discoloration. Ophthalmoscopic examination with red-free light testified to the complete hole formation. The most painstaking search failed to reveal the presence of peripheral holes or tears. Similarly, the history excluded the possibility of any traumatic origin of the macular hole.

The case presents many interesting features, first of which is the classic picture of the large, round, punched-out retinal hole with the simultaneous presence of an almost circular retinal detachment, approaching, but not reaching, the macular hole, without any peripheral lesion of the detached retina. The myopia amounted to only  $-4.50$  D, the patient was 46 years of age, a previous examination had not revealed any pathologic change in the retina. The cystic degeneration of the retina characteristic of high myopia and the senile retina were not noted. The hole itself was not partial, but included the entire fovea, the picture often observed over long periods, without the lesion leading to retinal detachment. In addition, about ten years previously, at the age of 36, the right eye, with about the same refraction, exhibited retinal detachment with multiple peripheral holes and visible cystic degeneration of the retina, at the last examination the macular area of this eye was free of any pathologic change, even in red-free light. The development of the macular hole and the subsequent separation of the retina were rather rapid, as the intelligent and reliable patient had noted visual deterioration only ten days prior to the examination. The subjective complaints are the more trustworthy considering that the



Retinal detachment with hole in the macula



patient had previously had a detached retina of the other eye and therefore had become a keen and anxious observer of herself. Any pathologic change would have had to manifest itself within a comparatively short period.

Perusal of the literature shows that the macular hole under discussion does not always represent the real macular hole as described in cases without associated detachment of the retina. In the classic form the macular hole is round, and punched-out margins and a floor of saturated red color are inevitable characteristics. The term "macular hole" is somewhat loosely applied. A pseudohole may exist in a honey-combed macula, and only examination in a red-free light will furnish the differentiation. A large cyst in which the anterior wall, the internal limiting membrane, is still intact is likely to simulate hole formation if not studied ophthalmoscopically with red-free light. Furthermore, the genuine macular hole represents a disk one-quarter or one-third the size of the average disk but may approach, or even exceed, the size of the disks. Another constant feature is that, the underlying choroid remaining intact, the ophthalmoscope offers a view of the choroid with the pigment epithelium intact, resulting in the saturated red color of the disk. In many instances, as previously mentioned, the size of the macular hole was that of a pinpoint and the floor of the hole was white, consequently, atrophic changes in the choroid must have been present, exposing the underlying sclera. In punctate holes the gap does not consist of the entire macula, possibly rupture of only one cystic space takes place. The hole is not necessarily located at the foveola itself but may be on its temporal or nasal slope. But the hole in some of the cases was not necessarily in the macula, the description often sounds as though the tear was paracentral (Rozenblyum<sup>15</sup>), or was a central hole between the macula and the disk. Finally, there were cases in which the macular hole was associated with peripheral tears. The latter should not be included with cases in which the macular hole is the only lesion present.

Peripheral holes may in rare cases occur without detachment. Recently, A. Knapp<sup>16</sup> reviewed the extensive literature and added 5 cases of his own to those reported. He stated that although this occurrence had been explained by the formation of chorioretinal adhesions, in 3 of his cases ophthalmoscopic study failed to reveal evidence of such changes. He excluded from his review the cases of macular hole without detachment. Macular holes are not to be included with retinal holes, since they are more benign than the peripheral holes.

<sup>15</sup> Rozenblyum, M. E. Detachment of the Retina with Tear in the Macula. *Vestnik oftal* 18 644, 1941.

<sup>16</sup> Knapp, A. Peripheral Retinal Holes Without Detachment, *Arch Ophth* 30 585 (Nov) 1943.

or tears, frequently do not cause detachment or the detachment remains flat and circumscribed and are nonprogressive, with a tendency to spontaneous reattachment. In the absence of simultaneous peripheral lesion extensive progressive detachment is infrequent, owing to the anatomic and physiologic peculiarities of the posterior pole. The smallness of the hole in the macula is not responsible for the nondevelopment of detachment, as relatively much smaller simple or multiple hole formation at the periphery is frequently the cause of extensive retinal detachment. The foveola is the thinnest area of the retina, according to Schwalbe. The thickening of the area surrounding the fovea reaches 0.49 mm, owing to an increase in the ganglion cell layer, the capillary net, absent in the foveola, appears at the margin. The large amount of nerve fibers are responsible for increased strength and elasticity explaining the circumscribed nature of the hole and the absence of detachment. In the peripheral parts of the retina the nerve fibers and the vessels are preventive forces against tears, therefore the tears are usually along, but never perpendicular to, these elements. The direction of the nerve fibers and the vessels around the macular area act as a ring-shaped barrier, preventing the extension of retinal separation, which, accordingly, takes a horizontally oval form at its inception. The motility of the eye may represent a further influential factor, by promoting the detachment at the periphery, especially in the upper temporal part and inhibiting it in the central portion. To the aforementioned forces preventing detachment in cases of macular hole Meisner added the lack of traction on the outer coat through the tendons of the muscles, in cases of peripheral holes the insertions of the extraocular muscles, especially the external and the oblique muscles, are a potent factor.

# TENOTOMY OF THE SUPERIOR OBLIQUE MUSCLE FOR HYPERTROPIA

Preliminary Report

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HACKENSACK, N J

**T**HE PURPOSE of this article is to describe a simple, effective and reliable surgical procedure for the cure of hypertropia associated with overaction of the superior oblique muscle

Hypertropia is due to weakness of one or more of the vertically acting extraocular muscles. This weakness may be acquired or congenital. It may be due to a structural weakness of the muscle itself, to an anomalous insertion of the muscle tendon or to abnormal innervation. Of 107 cases of congenital paralyses of the vertically acting extraocular muscles, Duane<sup>1</sup> found the superior rectus muscle affected in 58 (54 per cent), the inferior rectus muscle in 36 (33 per cent), the superior oblique muscle in 7 (7 per cent) and the inferior oblique muscle in 6 (6 per cent). In a critical analysis of 1,955 cases of anomalies of the extraocular muscles, White and Brown<sup>2</sup> found the vertically acting muscles affected in 36.6 per cent of the cases, and in the same order of involvement as that observed by Duane. Of 70 cases of congenital paralyses of the extraocular muscles Posey<sup>3</sup> found the superior rectus muscle affected in 25. On the other hand, Bielschowsky<sup>4</sup> and Davis<sup>5</sup> found the superior oblique muscle most often affected.

## CAUSE OF OVERACTION OF THE SUPERIOR OBLIQUE MUSCLE

Overaction of the superior oblique muscle occurs rarely as a primary spasm. It may be acquired or congenital. If acquired, it is generally

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1 Duane, A. Congenital Deviations of the Eyes, *Tr Am Ophth Soc* **12** 981-1001, 1912

2 White, J W, and Brown, H W. Occurrence of Vertical Anomalies Associated with Convergent and Divergent Anomalies. Clinical Study, *Arch Ophth* **21** 999-1009 (June) 1939

3 Posey, W C, cited by Dunnington<sup>sc</sup>

4 Bielschowsky, A. Lectures on Motor Anomalies, Hanover, N H, Dartmouth College Publications, 1940

5 Davis, W T. Paresis of Right Superior Oblique and of Left Superior Rectus Muscle, *Arch Ophth* **32** 372-380 (Nov ) 1944



due to surgical trauma to the homolateral inferior oblique muscle. If congenital, it is usually secondary to weakness of the homolateral inferior oblique muscle or to weakness of the contralateral inferior rectus muscle. Since these two muscles, the inferior oblique and the inferior rectus, are affected in about 39 per cent of congenital anomalies of the vertical-acting extraocular muscles, according to Duane's figures previously cited, spasm of the superior oblique muscle potentially occurs in this percentage of congenital vertical anomalies. Viewed in this light, spasm of the superior oblique muscle becomes an important factor in the vertical imbalances, vying in frequency with overaction of the inferior oblique muscle—a condition which occurs potentially in 61 per cent of the vertical imbalances.

#### SYMPTOMS AND OBJECTIVE FINDINGS ASSOCIATED WITH OVERACTION OF THE SUPERIOR OBLIQUE MUSCLE

Hughes and Bogart<sup>6</sup> stated that patients with overaction of the superior oblique muscle experience extreme discomfort, vertical diplopia and difficulty of fusion, especially in the lower fields of vision, and exhibit head tilting and torsion of the vertical axis of the affected eye. Patients with fusion may close one eye or turn the head or the entire body to avoid turning the eyes into the field of the overactive superior oblique muscle.

A hypertropia associated with overaction of the superior oblique muscle is usually associated with an exotropia or an exophoria. Occasionally one sees a patient with an overactive superior oblique muscle which is not associated with a horizontal tropia. These patients usually have fusion and depth perception in all directions of gaze except in the field of action of the overactive superior oblique muscle.

For the purpose of this article, all vertical deviations can be placed in one of three groups. In group 1, overaction of one or both inferior oblique muscles is present. This overaction usually is secondary to paresis of the contralateral superior rectus muscle or the homolateral superior oblique muscle. Vertical anomalies of this type are frequent and are improved by a tenotomy, a myectomy or a recession of the overactive inferior oblique muscle, irrespective of which muscle (the contralateral superior rectus or the homolateral superior oblique) was originally paretic.

In group 2, the hypertropia is associated with overaction of one or both superior oblique muscles. Cases of this type are less common than those of group 1, and the deviation can be improved or entirely cured by a tenotomy or a tenectomy of the overactive muscle.

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6 (a) Hughes, W. L., and Bogart, D. W. Recession of Trochlea in Overaction of Superior Oblique, *Am J Ophth* **25** 911-915 (Aug.) 1942. (b) Hughes, W. L. Recession of the Trochlea for Reducing Action of Superior Oblique, *ibid* **27** 1123-1131 (Oct.) 1944.

Hypertropia associated with an overactive superior oblique muscle can be differentiated from that produced by an overactive inferior oblique muscle by rotating the eyes temporarily. If the right superior oblique muscle is overactive, a left hypertropia will be present, which increases by having the patient look to the left. If the right inferior oblique muscle is overactive, a right hypertropia will be present, which increases when the patient looks to the left. In other words, if the right eye shoots upward in adduction, the right inferior oblique muscle is overactive. If it shoots downward, the right superior oblique muscle is overactive. These two conditions may be further differentiated by bringing the eyes to the up or to the down position in eyes directed to the left. A left hypertropia, due to an overactive right superior oblique muscle, increases as the eyes are carried from the horizontal plane in eyes directed to the left to a lower plane in eyes directed down and to the left. If the right inferior oblique muscle is overactive, the right hypertropia will increase as the eyes are carried from the horizontal plane in eyes directed to the left to a higher plane in eyes directed up and to the left. In cases of long-standing hypertropia the deviation may be almost the same when the eyes are directed up and to the left as when the eyes are directed down and to the left.

In group 3 may be placed all other types of hypertropia not associated with overaction of the oblique muscles. This group includes spasms of the vertically acting rectus muscles, combined insufficiencies and hypertropias not referable to paresis or spasm of any definite muscle.

#### TREATMENT OF HYPERTROPIA ASSOCIATED WITH OVERACTION OF THE SUPERIOR OBLIQUE MUSCLE

If the vertical deviation is 5  $\Delta$  or less, prisms may give the patient comfort. Fusion exercises may increase the patient's ability to overcome his symptoms. If neither of these two forms of treatment gives relief, operation is indicated.

As a general rule, all surgical procedures on the vertically acting extraocular muscles are directed toward (1) strengthening the weak muscle, (2) weakening the direct antagonist, or (3) weakening the yoke muscle.

In cases of paralysis of the inferior rectus muscle associated with overaction of the contralateral superior oblique muscle, one may (1) strengthen the inferior rectus muscle by advancement, tucking or resection, (2) weaken the homolateral superior rectus muscle by tenotomy or recession or (3) weaken the contralateral superior oblique muscle by recession of its pulley or by tenotomy or tenectomy of its reflected tendon.

In cases of paralysis of the inferior oblique muscle associated with overaction of the homolateral superior oblique muscle, one may (1)

strengthen the action of the inferior oblique muscle by tucking, resection or advancement, (2) weaken the action of the contralateral superior rectus muscle by tenotomy or recession, or (3) weaken the homolateral superior oblique muscle by recession of its pulley or by tenotomy or tenectomy of its reflected tendon

In cases of paralysis of the inferior rectus muscle, White,<sup>7</sup> Dunnington,<sup>8</sup> Duane,<sup>9</sup> and Bielschowsky<sup>4</sup> advocated shortening the affected inferior rectus muscle. If this procedure is not adequate, White<sup>7</sup> advocated recession of the homolateral superior rectus muscle. In cases of paralysis of the inferior oblique muscle, Wheeler,<sup>10</sup> White<sup>7</sup> and Dunnington<sup>8</sup> advocated shortening the affected muscle by tucking, resection or advancement. If this is not adequate, White and Dunnington advocated recession or tenotomy of the contralateral superior rectus muscle.

Hughes and Bogart<sup>6a</sup> are the only authors who have advocated weakening an overactive superior oblique muscle in anomalies of the vertically-acting extraocular muscles. In 1942<sup>6a</sup> they advocated recession of the pulley of the superior oblique muscle, stating that this is the only operation of the kind designed for this purpose. This operation requires a cutaneous incision, is technically not easy and has to be performed in a field traversed by the supratrochlear and infratrochlear nerves, the angular artery and vein and the terminal branches of the ophthalmic artery and vein. After the pulley and the adjacent periosteum have been freed from the underlying bone, the periosteum bearing the pulley must be pushed back into the orbit 10 to 15 mm. Because the periosteum is not sutured in place and one cannot be sure where the pulley will become attached, one has little control over the final result. In the average patient, if the pulley becomes permanently

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7 White, J. W. (a) The Choice of the Fixating Eye in Paralytic and Non-Paralytic Strabismus, *Tr Am Ophth Soc* **41** 319-324 1943, (b) Indications for Treatment for Combined Lateral and Vertical Strabismus, *Arch Ophth* **10** 585-592 (Nov) 1933, (c) A Review of Twenty-Seven Years with the Obliques, *Tr Pacific Coast Oto-Ophth Soc* **26** 112-131, 1941, (d) Surgery of the Inferior Oblique at or near Its Insertion, *Tr Am Ophth Soc* **40** 118-126, 1942 (e) Paralysis of the Superior Rectus and the Inferior Oblique Muscle of the Same Eye, *Arch Ophth* **27** 366-371 (Feb) 1942, (f) Paralysis of Superior Rectus Muscle, *Tr Am Ophth Soc* **31** 551, 584, 1933.

8 Dunnington, J. H. (a) Diseases of the Extraocular Muscles in Blumer, G. *Practitioner's Library of Medicine and Surgery*, New York, D. Appleton-Century Company, Inc., 1937, pp 303-328, (b) Hyperphoria Its Etiology, Diagnosis and Treatment, *Am J Ophth* **14** 1140 (Nov) 1931, (c) Tenotomy of the Inferior Oblique, *Tr Am Ophth Soc* **27** 277, 1929, (d) Surgical Treatment of Strabismus, *New York State J Med* **38** 12-18 (Jan) 1938, (e) Surgical Treatment of Strabismus, *M Rec* **35** 877-880 (June) 1941.

9 Duane, A., cited by Dunnington<sup>8b</sup>

10 Wheeler, J. M. Advancement of Superior Oblique and Inferior Oblique Ocular Muscles, *Tr Am Ophth Soc* **32** 232-244, 1935.

attached 10 mm behind its previous point of attachment, it will be at or behind the equator of the globe. In this position, the superior oblique muscle can act only as an intorter of the vertical axis of the globe in the primary position.

Tenotomy or tenectomy of the superior oblique muscle has never been performed to relieve hypertropia in a patient with overaction of this muscle. Bonnet<sup>11</sup> tenotomized the oblique muscles to cure myopia. Von Graefe<sup>12</sup> advocated a "hands-off" policy with regard to operative procedures on the oblique muscles. Wilder<sup>13</sup> tenotomized the reflected tendon of the superior oblique muscle through a conjunctival incision on a cadaver but, so far as I know, never on a living patient. He mentioned a method for exposing and severing the tendon of the superior oblique muscle through a cutaneous incision, which he said would produce complete paralysis of the muscle. Spaeth<sup>14</sup> and Peter<sup>15</sup> cited the same procedure. Duane<sup>16</sup> simply stated that tenotomy of the superior oblique muscle may be done through a cutaneous incision through the brow. White<sup>8c</sup> stated that he had never seen a case in which tenotomy of the superior oblique muscle was indicated. Spaeth<sup>14</sup> expressed the belief that "tenotomy of the superior oblique should never be done except under the most extraordinary circumstances." Peter<sup>15</sup> stated that operation on the insertion of the superior oblique muscle is a questionable procedure. Dunnington<sup>8</sup> expressed the opinion of most authors when he stated that "it is not feasible to weaken the superior oblique muscle." It would seem, therefore, that today most ophthalmic surgeons are agreed that tenotomy of the superior oblique muscle is out of favor. It is interesting to note that tenotomy of the inferior oblique muscle was similarly regarded thirty or forty years ago.

In cases of paresis of the inferior rectus muscle or of the inferior oblique muscle associated with overaction of the superior oblique muscle, the idea that tenotomy of the superior oblique is difficult or dangerous has restricted ophthalmic surgeons to three surgical procedures in the relief of these conditions, namely, shortening the paretic inferior rectus muscle, weakening the homolateral superior rectus muscle and shortening the paretic inferior oblique muscle. None of these procedures is entirely satisfactory. In some cases of overaction

11 Bonnet, G, cited by Dunnington<sup>8c</sup>

12 Von Graefe, A, cited by White<sup>7</sup>

13 Wilder, W. H., in Wood, C. A. *A System of Ophthalmic Operations*, Chicago, Cleveland Press, 1911, vol 1, p 703

14 Spaeth, E. B. *Principles and Practice of Ophthalmic Surgery*, Philadelphia, Lea & Febiger, 1944, p 191

15 Peter, L. C. (a) *Extraocular Muscles*, Philadelphia, Lea & Febiger, 1941, (b) in discussion on White<sup>7d</sup>

16 Duane, A., in Fuchs, E. *Text-Book of Ophthalmology*, ed 8, Philadelphia, J. B. Lippincott Company, 1924, p 939

of the superior oblique muscle, there is no demonstrable weakness of either the inferior rectus or the inferior oblique muscle, making it impossible to decide which of these two muscles should be strengthened. In cases of paresis of the inferior oblique muscle associated with overaction of the superior oblique muscle, resection, advancement or tucking of the paretic inferior oblique muscle is more effective if combined with tenotomy of the superior oblique. In cases of paresis of the inferior rectus, resection or shortening of this muscle lessens the vertical imbalance but cannot cure that part of the hypertropia due to overaction of the contralateral superior oblique muscle, especially when the paretic eye is used for fixation. Also, shortening the inferior rectus muscle has a tendency to narrow the palpebral fissure and to restrict the action of the superior rectus muscle. Recession of the homolateral superior rectus muscle in cases of paresis of the homolateral inferior rectus muscle or of the contralateral inferior oblique muscle tends to widen the fissure and to restrict the upward rotation of the globe. Tenotomy of the superior oblique muscle does neither of these things. It is not a difficult procedure. On the contrary, it is simpler and easier to perform than tenotomy, myectomy or recession of the inferior oblique muscle. It does not lead to torsional difficulties, to changes in the width of the fissure or to complete paralysis of the superior oblique muscle. The operation can be graded to meet the demands of each case with the same degree of accuracy and confidence as in tenotomy of the inferior oblique muscle. It is the procedure of choice in cases of paresis of the contralateral inferior rectus muscle or of paresis of the homolateral inferior oblique muscle when overaction of the superior oblique muscle is a factor in the hypertropia.

When one has a choice, it is fundamentally sounder surgical judgment to elect to weaken an overactive strong muscle, so that it will balance with an abnormally weak one, than to attempt to strengthen the weak muscle so that it will balance with the power of an overactive one. Fulton<sup>17</sup> stated that stretching a muscle increases its lifting power. The same thing cannot be said for resection or shortening of a weak muscle, otherwise the lifting power of a weak muscle would be progressively increased with each additional millimeter of resection until its ultimate power would be reached only when it was completely excised.<sup>1</sup>

Tenotomy of the superior oblique muscle requires use of a general anesthesia in children. In adults only local anesthesia, induced with drop instillation of cocaine, is necessary. The operative field is practically bloodless and the operation painless unless unnecessarily strong traction is made on the tendon. The procedure is simple, easy and can be completed in five minutes. The operation leaves no visible

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<sup>17</sup> Fulton J. F. *Muscular Contraction and Reflex Control of Movement*, Baltimore, Williams & Wilkins Company, 1926

sca1, for the incision is made through the conjunctiva under the upper lid. The only difficulties associated with the operation are the uncertainty of identifying the reflected tendon and the question of deciding how much tendon to excise. The first difficulty is due to the large amount of Tenon's capsule and areolar tissue about the tendon. The second difficulty is one inherent in all operations on extraocular muscles.

#### ANATOMY OF THE SUPERIOR OBLIQUE MUSCLE

The superior oblique muscle originates at the apex of the orbit from the periosteum close to the annulus of Zinn. From its origin it runs

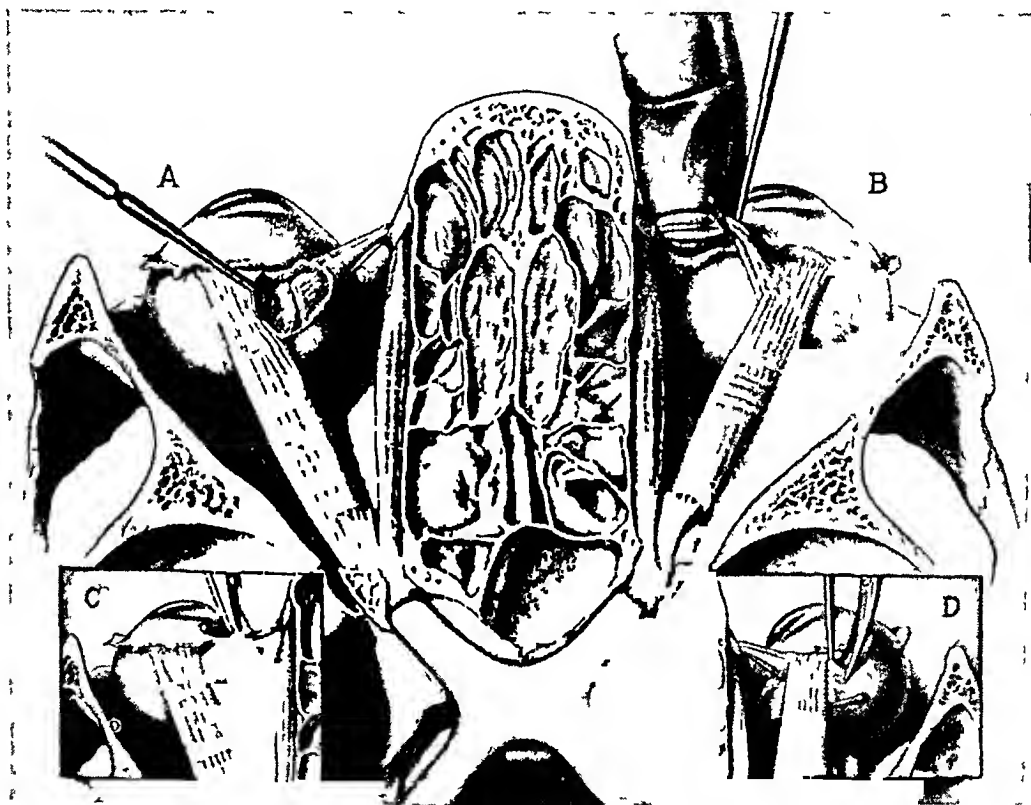


Fig 1—Horizontal section through the orbits (Tenon's capsule removed)

*A*, tenotomy of the left superior oblique muscle close to the nasal border of the superior rectus muscle. The sheath of the reflected tendon of the superior oblique has been opened and the superior rectus retracted to expose the tendon. Note the numerous fibrillar adhesions between the tendon and its sheath.

*B*, execution of the traction test. With traction on the muscle hook, and with the index finger over the pulley, the surgeon can feel the reflected tendon of the superior oblique muscle extending like a cord from the pulley toward the muscle hook. This will positively identify the tendon and its sheath.

*C*, site of section of the tendon of the superior oblique and its sheath for complete paralysis of the muscle.

*D*, position of muscle hook and scissors for tenotomy of the superior oblique at its insertion.

directly forward about 40 mm along the superior nasal wall of the orbit to its pulley, just inside the orbital margin (fig 1*A*). Here it turns backward at an angle of about 55 degrees to its previous course and

becomes inserted into the posterior part of the superior lateral quadrant of the globe. The tendon of the superior oblique muscle begins 8 to 10 mm behind the pulley and, in passing through the latter, is compressed into a fibrous cord about 1 mm wide and 2 mm thick. After leaving the pulley, the tendon becomes wider and thinner as it approaches the globe. As it passes under the superior rectus muscle, it is only 2 or 3 mm from the scleral attachment of this muscle. In operations, it is easy to pick up and incise the tendon of the superior oblique muscle at this point (fig 1A). Under the superior rectus the tendon of the superior oblique muscle fans out and becomes so thin that it is transparent. Its insertion to the sclera is a curved line about 10 to 12 mm long, with the concavity directed toward the pulley. The posterior end of this line is about 4 mm from the optic nerve, while the anterior end is about 5 mm from the lateral end of the attachment of the superior rectus muscle. The entire length of the tendon of the superior oblique muscle is 28 to 30 mm and, with the eye in the primary position, is distributed as follows

	Mm
Length of tendon behind pulley	9
Length of tendon in pulley	4
Length of tendon from pulley to medial border of superior rectus	9
Length of tendon under superior rectus	5
Total length of tendon	30

The entire tendon of the superior oblique muscle is covered with a layer of areolar tissue, which extends from Tenon's capsule to the pulley and from the pulley backward along the superior oblique muscle for a distance of 8 to 10 mm. This tissue forms a sheath 2 to 3 mm thick about the tendon, so that the tendon and its sheath together are about 5 to 6 mm in diameter. Between the tendon and its sheath is a potential space, corresponding to that between the sclera and Tenon's capsule. Material, such as warm starch solution, injected under Tenon's capsule found its way from Tenon's capsule into this potential space.

The sheath of the tendon is remarkable for its many attachments, which extend to the sheath of the levator muscle, to the sheath of the superior rectus muscle, to the conjoined sheaths of the levator and the superior rectus muscle and to Tenon's capsule behind, below and laterally. This sheath completely encloses the pulley, from which extensions can be seen to pass to the septum orbitale, in front, to the muscle fibers of the superior oblique, behind, and to the periosteum, nasally. If the tendon of the superior oblique is dissected free of its sheath, it will be noted that the former is connected to the latter all along its course by many delicate areolar tissue fibrillae (figs 1A and 2). These adhesions undoubtedly prevent the tendon from retracting too far within its sheath.

after the tendon has been severed from the globe. It is the presence of these fibrillar attachments between the tendon and its sheath, on the one hand, and the many attachments of the sheath to the globe, on the other, which prevent the development of complete paralysis of the superior oblique muscle when its tendon is cut or partially removed.

In operations, the amount of weakening of the superior oblique muscle can be varied by the amount of tendon removed. If a slight effect is desired, it is necessary only to cut through the tendon close to the globe. If a larger effect is desired, some of the tendon must be removed. If complete paralysis is required, a portion of the entire sheath and its

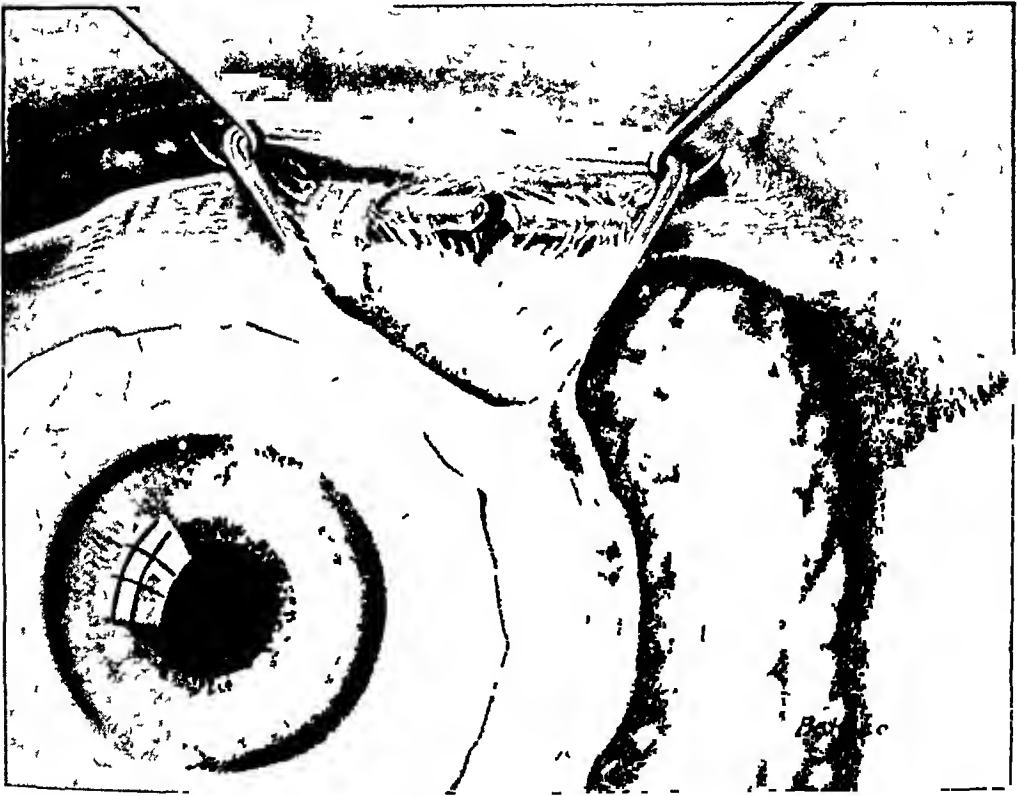


Fig 2—Illustration showing why complete paralysis does not develop after tenotomy of the superior oblique muscle. Note that the sheath of the reflected tendon of the superior oblique muscle is fused with Tenon's capsule, which has been opened on the nasal side of the superior rectus muscle to expose the two ends of the severed tendon of the superior oblique. Note the many adhesions between this tendon and its sheath. It is the presence of these numerous adhesions between the reflected tendon of the superior oblique muscle and its sheath, on the one hand, and the several attachments of the sheath to the globe, on the other, which prevents complete paralysis of the superior oblique muscle from developing after its tendon has been severed.

tendon, close to the pulley (fig 1 C), should be excised. The truth of these statements was tested on a cadaver by the following experiment:

On one eye, a routine tenotomy of the superior oblique muscle was done through the conjunctiva on the nasal side of the superior rectus muscle. Then the roof of the orbit was removed, and the levator and superior rectus muscles were turned back over the globe to expose Tenon's capsule. Even though the tendon of the superior



oblique muscle had been thoroughly and completely incised by the previous operation, it was noted that backward traction on the superior oblique muscle caused the globe to be depressed and intorted. This traction was repeated several times, with the same result. Tenon's capsule was then removed and the sheath of the tendon of the superior oblique opened to make sure that no strands of the tendon remained between the globe and the pulley. This showed that only the sheath remained intact and that the cut tendon had retracted toward the pulley within its sheath. With further traction on the superior oblique muscle, the tendon was pulled through the pulley and 2 to 3 mm behind it. Even then, with the cut end of the tendon in this abnormal position, traction backward on the superior oblique muscle still caused movement of the globe because of the attachments of its sheath to the globe, on the one hand, and the adhesions between the sheath and the superior oblique tendon, on the other.

The roof of the other orbit was then removed, and the tendon of the superior oblique muscle, after identification, was completely incised at its insertion under the superior rectus (fig 1D). Traction on the superior oblique muscle again caused intorsion and downward movement of the globe, showing that the superior oblique continued to move the globe via its sheath even though the tendon had been completely severed from the sclera. Before ending the experiment, the tendon and its sheath were both completely cut close to the pulley (fig 1C). After this traction on the superior oblique muscle failed to have any effect on the globe.

This experiment demonstrated that tenotomy of the superior oblique muscle within its sheath only weakens its action but that cutting completely through the tendon and its sheath close to the pulley produces complete paralysis.

#### OPERATIVE PROCEDURE FOR TENOTOMY OF THE SUPERIOR OBLIQUE MUSCLE

The tendon of the superior oblique muscle may be cut through a cutaneous or through a conjunctival incision. If the conjunctival route is selected, the tendon may be severed under Tenon's capsule either on the lateral or on the medial side of the superior rectus muscle. The latter method is preferable, for three reasons. First, the tendinous insertion of the superior rectus need not be exposed, second, the tendon of the superior oblique is well forward at this point and is compressed into a band 6 to 7 mm wide, third, there are no arteries, veins, nerves or other important structures here which might be injured. If the superior rectus has to be exposed, as in cases of resection of this muscle for paralysis of elevation, the tendon of the superior oblique can be cut at its insertion (fig 1D) or readily picked up and severed under the superior rectus muscle. Tenotomy of the superior oblique at its insertion is difficult and uncertain, because one cannot be sure that all the fibers of the tendon have been completely severed from the globe. Tenotomy of the superior oblique muscle is best performed on the nasal side of the superior rectus muscle by the technic to be described.

1 A self-retaining speculum or a Desmares lid retractor is inserted under the upper lid and the globe pulled down by means of a suture passed through the limbus at 12 o'clock. The conjunctiva and Tenon's capsule are incised for 10 to 12 mm in the superior nasal fornix and the tissue between Tenon's capsule and the sclera undermined 10 to 12 mm posteriorly.

2 A muscle hook is passed 10 to 12 mm backward into the wound between Tenon's capsule and the sclera, with the hook flat against the latter (fig 3), and the point is then turned upward toward the roof of the orbit, so as to engage the reflected tendon of the superior oblique muscle and its sheath.

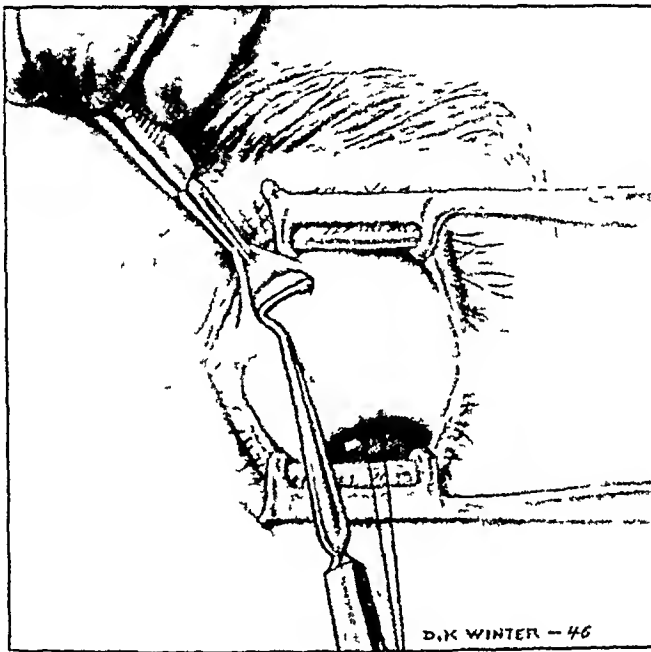


Fig 3—Insertion of the muscle hook for tenotomy of the left superior oblique. An incision has been made through the conjunctiva and Tenon's capsule and the latter undermined. Note the position of the point of the hook.

3 Before the contents are delivered on the hook into the wound, one should make sure, by means of the traction test (to be described), that the tendon and its sheath are on the hook (figs 1 B and 4).

4 If the traction test gives a positive result, the reflected tendon and its sheath, together with a good deal of Tenon's capsule, will be on the hook. To identify the tendon, most of the tissue on the hook must be lifted off with forceps until a glistening, pearly white cord, the tendon of the superior oblique, is seen. If local anesthesia is used, the tendon can be positively identified by asking the patient to look up and down. If the tendon is on the hook, one will see it slide back and forth over the shank of the hook as the eye moves up and down.

5 After the tendon is identified, it is completely incised between the hook and the superior rectus. If a larger effect is desired, a hemostat is

placed on the tendon and an incision made close to the hemostat on either side, thus removing 3 to 5 mm of tendon (fig 5) Only the tendon should be excised, leaving the sheath behind If more effect is desired, 6 to 8 mm of tendon should be removed

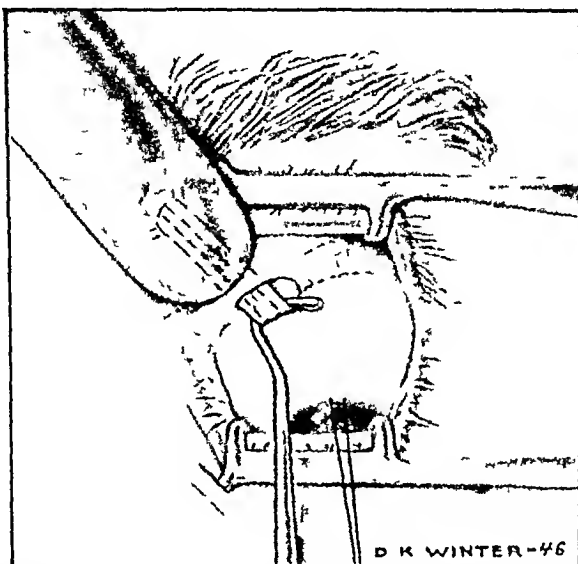


Fig 4—Execution of the traction test The tendon of the superior oblique and its sheath have been engaged on the muscle hook and pulled into the wound If the tendon has been picked up on the hook, the palpating finger, held over the pulley, should feel a cordlike band extending from the pulley to the shank of the muscle hook

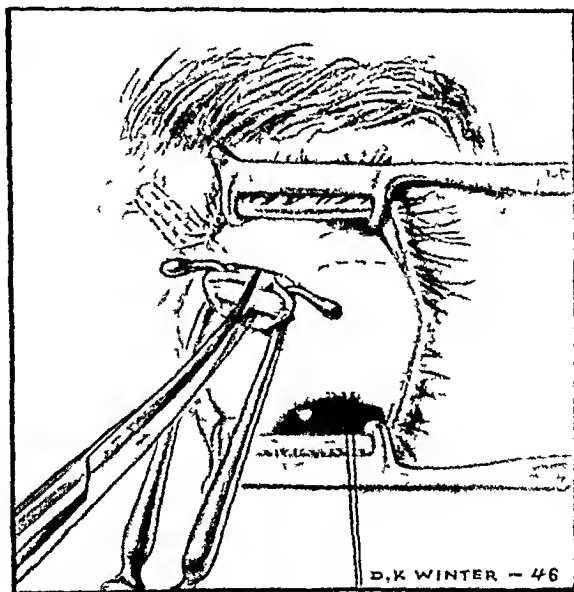


Fig 5—Cutting the tendon of the superior oblique muscle The sheath of the tendon has been removed by blunt dissection and the latter exposed on two muscle hooks For a simple tenotomy, the tendon is cut through with scissors, for a tenectomy, a mosquito forceps is applied to the tendon and the latter cut on either side of the clamp

6 The conjunctiva is closed by means of one or two single interrupted plain surgical gut sutures and a monocular dressing applied for twelve to twenty-four hours

#### TRACTION TEST

As previously stated, one difficulty associated with this operation is identification of the tendon of the superior oblique muscle. This difficulty is readily solved by use of the traction test, which is performed as follows. After the conjunctival wound has been made and Tenon's capsule undermined, a muscle hook is passed into the wound and brought forward. On the hook will be a mass of unfamiliar tissue, within the confines of which may be the tendon of the superior oblique muscle. Since one cannot be sure that the tendon is on the hook, one should determine definitely whether it is present in the tissue thus engaged before making any needless dissection. This is done by palpating the pulley through the skin with the index finger of one hand, while the other hand pulls forward on the hook (fig 1 *B*). If the tendon or its sheath is on the hook, the index finger over the pulley will feel a cordlike structure extending from the pulley to the hook. Each time traction is made on the hook, the palpating finger over the pulley will feel a tug on the tendon. This test positively identifies the tendon and/or its sheath. If the tissues on the hook are now gently lifted off with forceps, one will find the pearly white, glistening tendon of the superior oblique muscle, which at this point is gathered into a cord about 2 mm in diameter.

A word of caution should be given. The traction test is not infallible and may give a positive result if only a few fibers of the tendon or its sheath are engaged on the hook. If the hook is passed 10 to 12 mm backward and brought forward, as previously directed, the tendon should always be engaged. If the tendon is not picked up on the hook on the first trial, the attempt should be repeated until the surgeon is certain that the tendon has been identified. Needless to say, if the tendon itself is not sectioned, but only a few fibers of its sheath are severed, the effect will be negligible. The only positive identification of the tendon is its pearly white, glistening luster. The sheath of the superior oblique muscle is white and semitendinous, but not glistening.

#### AMOUNT OF TISSUE TO BE REMOVED

It is impossible at this time to be dogmatic about how many prism diopters of hypertropia will be corrected by a tenotomy or by a tenectomy because of the intrinsic nature of all tenotomies of the extraocular muscles. However, it is safe to say that a tenotomy will produce less effect than a tenectomy, that a larger tenectomy will produce a greater effect than a smaller one and that the effect will be greater, the closer

the tenotomy or the tenectomy is done to the pulley. In other words, the effect may be varied depending on the amount of tendon removed and the place of its removal. If the tendon is cut close to the globe, the effect will be less, if cut close to the pulley it will be greater. If both the tendon and its sheath are cut close to the pulley, complete paralysis may result. As a general rule, the following suggestions will not lead one far astray: (1) For a deviation of 5 to 10  $\Delta$ , a simple tenotomy is done, (2) for a deviation of 10 to 20  $\Delta$ , 3 to 5 mm of the tendon is removed, (3) for 20 to 30  $\Delta$  of deviation, 5 to 8 mm of the tendon is excised,<sup>18</sup> and for (4) complete paralysis of the superior oblique, a part of the tendon and its sheath should be excised close to the pulley through a cutaneous incision.

#### INDICATIONS FOR TENOTOMY OF THE SUPERIOR OBLIQUE MUSCLE

Tenotomy of the superior oblique muscle should be performed whenever the muscle is overactive and the symptoms of the hypertropia cannot be relieved by nonoperative means. This operation may be combined with resection, advancement or tucking of the inferior oblique muscle or with shortening operations on the contralateral inferior rectus muscle. In cases of paralysis of the third nerve and in cases of so-called paralysis of elevation, in which the inferior oblique and superior rectus muscles are weak, the superior oblique muscle should be tenectomized to increase the relative lifting power of the inferior oblique muscle. If the superior rectus muscle is being resected for relief of paralysis of elevation, it is a simple matter to excise a part of the tendon of the superior oblique under the superior rectus muscle at the same time.

#### REPORT OF CASES

CASE 1—Mrs. M. A., aged 34, a billing clerk, stated that she had cut her right eye in childhood with a piece of glass. Later the right eye crossed, when she was 10 years old an operation was done to straighten the eye, but for the past fifteen years it had turned out. Examination of the right eye showed a scar of the cornea, which reduced her vision to 2/200, sinking of the caruncle and almost complete paralysis of the internal rectus muscle. An exotropia of 50  $\Delta$  for 20 feet (6 meters) and for 13 inches (33 cm) was present with the eyes in the primary position, the deviation measured 40  $\Delta$  in eyes up and 55 to 60  $\Delta$  in eyes down. In addition, there was a pronounced overaction of the right superior oblique muscle which produced a left hypertropia of 10  $\Delta$  with eyes in the primary position, increasing to 20  $\Delta$  with eyes directed to the left and to 25  $\Delta$  with eyes directed down and to the left. In June 1939 a recession of the external rectus and a resection of the internal rectus muscle on the right eye was done for correction of the exotropia. At the same time the overactive superior oblique muscle was tenotomized at its insertion under the superior rectus and the scar of the cornea tattooed. After

<sup>18</sup> I have never removed more than 7 mm at one time.

operation there was considerable edema of the lids and conjunctiva, which produced 3 to 4 mm. of ptosis of the upper lid. In two months the ptosis had cleared up. Six months after the operation, the patient had a cosmetically perfect result when the eyes were in the primary position, with slight limitation of abduction in the right eye. A suggestion of overaction of the superior oblique was noted when the right eye was rotated down and nasally. When she was last seen, seven years later, a moderate overaction of the right superior oblique muscle persisted.

*Comment*—The tenotomy of the superior oblique muscle in this case was my first operation of the kind. It was gratifying to note that the overaction of the superior oblique muscle was reduced without producing complete paralysis, even after seven years. The postoperative edema and ptosis of the upper lid were at first thought to be due to the operation on the tendon of the superior oblique muscle. Instead, the ptosis may have been due to the operation on the internal and external rectus muscles, to the tattooing of the cornea or to a combination of all three operations. Ptosis did not develop in any of the other cases in which the superior oblique was tenotomized.

CASE 2—P. I., a girl aged 6, had exotropia of three years' standing. Her general health was good. Birth was by cesarean section. There was no family history of exotropia or esotropia. Vision was 20/20 in each eye, and except for the muscular anomaly her eyes were entirely normal. Refraction with atropine cycloplegia revealed a small compound hyperopic astigmatic error. There was no limitation of abduction or adduction. For 20 feet there was variable exotropia, being  $20\Delta$  in eyes up,  $30\Delta$  in eyes straight ahead and  $40\Delta$  in eyes down. For 13 inches the exotropia was  $30\Delta$  in eyes up,  $40\Delta$  in eyes straight ahead and  $50\Delta$  in eyes down. For both 20 feet and 13 inches there was double hypertropia, with the left hypertropia predominating. In eyes right there was right hypertropia of  $10\Delta$ , due to overaction of the left superior oblique muscle, and in eyes left, a left hypertropia of  $15\Delta$ , due to overaction of the right superior oblique muscle (fig 6a, b and c). The right hypertropia decreased in eyes up and right and increased in eyes down and right. The left hypertropia decreased in eyes up and left and increased in eyes down and left. Careful measurements of the deviation in the "corners" were not made because of poor cooperation. It was estimated that the right hypertropia in eyes down and right was 15 to  $20\Delta$  and the left hypertropia in eyes down and left was 20 to  $25\Delta$ . A diagnosis was made of paresis of each inferior rectus muscle with overaction of each superior oblique muscle, the right superior oblique muscle being the more overactive. The patient was seen in consultation with Dr. J. H. Dunnington, who concurred in this diagnosis. In December 1941 a resection of the right internal rectus muscle and a recession of the right external rectus muscle were done, together with a tenotomy of both superior oblique muscles at their insertions. At the operation Tenon's capsule was disturbed as little as possible. After operation there was no ptosis and scarcely any reaction in the left eye except for a little redness under the upper lid. The conjunctiva of the right eye presented moderate reaction over the internal and external rectus muscles. One month after the operation there was esotropia for 20 feet and 13 inches of 5 to  $11\Delta$ , with moderate overaction of the right superior oblique muscle in eyes left. On the synoptoscope there was an esotropia of

6 to 11  $\Delta$ , with a left hypertropia of 3  $\Delta$ . Because the patient had anomalous projection, fusion exercises were not given. Two months after operation there was orthophoria for 20 feet with the eyes in the primary position. At 13 inches there was moderate left hypertropia with eyes directed to the left, owing to persistent overaction of the right superior oblique muscle. Three years after the operation there was still overaction of each superior oblique muscle. The horizontal position of the eyes was excellent cosmetically, and the near point of convergence was fair. Four years after the operation there were for 20 feet a left hypertropia of 4  $\Delta$  and an esophoria of 5  $\Delta$  with the eyes in the primary position and the right eye



Fig 6 (case 2)—Exotropia with overaction of each superior oblique muscle. Eyes before operation (a-c), eyes four years after operation (d-f).

(a) Both eyes looking to the right. Note that the right eye is looking up and to the right, while the left eye is directed down and to the right, owing to overaction of the left superior oblique muscle.

(b) Right eye looking straight ahead, and the left eye looking up and out.

(c) Both eyes looking to the left. Note that the right eye is directed downward, owing to overaction of the right superior oblique muscle.

(d) Both eyes looking to the right, with a residual overaction of the left superior oblique muscle after operation. Compare with a.

(e) Both eyes looking straight ahead. Note reduction of left hypertropia after operation as seen by comparing b and e.

(f) Both eyes looking to the left, with a residual overaction of the right superior oblique. Compare with c.

fixing While the patient was fixating a light at 20 feet, rotation of the eyes to the right brought out a right hypertropia of 8  $\Delta$ , while rotation of the eyes to the left changed the right hypertropia to a left hypertropia of 10  $\Delta$  The right eye was used for fixation in eyes directed to the left, and the left eye, in eyes directed to the right (fig 6*d, e, f*) For 13 inches the measurements were as follows

Eyes up and right	X' 7 $\Delta$ *	RH' 2 $\Delta$
Eyes right	No X'	RH' 8 $\Delta$ (fig 6 <i>d</i> )
Eyes down and right	XT' 7 $\Delta$	RHT' 12 $\Delta$
Eyes straight ahead	No X' or S'	Double HT' (fig 6 <i>e</i> )
Eyes up and left	X' 8 $\Delta$	LH' 2 $\Delta$
Eyes left	X' 7 $\Delta$	LHT' 12 $\Delta$ (fig 6 <i>f</i> )
Eyes down and left	XT' 12 $\Delta$	LHT' 20 $\Delta$

\* In this tabulation, and in the accompanying tabulations, X and X' indicate exophoria for distant and near vision, XT and XT', exotropia for distant and near vision, S and ST and S' and ST', esophoria and esotropia for distant and near vision, respectively, RH and RHT and RH' and RHT', right hyperphoria and right hypertropia for distant and near vision, respectively, and LH and LHT and LH' and LHT', left hyperphoria and left hypertropia for distant and near vision, respectively

The near point of convergence was 120 mm, and the patient did not have first degree fusion Abduction and adduction were good

*Comment*—The persistent overaction of each superior oblique muscle after operation was most likely due to incomplete tenotomy In tenotomy of the superior oblique muscle at its insertion, it is difficult to be certain that all the fibers have been severed from the globe because the insertion extends so far behind the equator Later experience with this operation has taught me that a 5 mm tenectomy on the nasal side of the superior rectus muscle would have produced a better result in this case Another operation to remove a part of the tendon of each superior oblique at this time would most likely have reduced the hypertropia This correction had been suggested, but permission for operation was refused by the parents Operation has not been urged because the child has no symptoms referable to her vertical imbalance and because in the primary position her eyes are cosmetically straight It has been contended by some surgeons that in cases of combined vertical and horizontal deviations the vertical deviation should be corrected first Other surgeons have suggested that the horizontal deviation be corrected first Both groups have insisted that if this is done the second component of the deviation may correct itself In this case, correction of the horizontal deviation affected in no way the vertical deviation

CASE 3—N P, a boy aged 3½ years, had had exotropia of the left eye since 1 year of age, which had been getting worse for six months For several months the parents had noticed that the child held his head turned to the right side when looking closely at objects The general health was good There was no family history of esotropia or exotropia Examination showed that the right eye was the fixing eye with both eyes uncovered but that the left eye would fix if the right eye was covered Refraction with atropine cycloplegia revealed a small, simple hyperopic refractive error Abduction and adduction were good in each eye The near point of convergence was remote and could not be measured There was a variable



exotropia for 20 feet and 13 inches, being  $20\Delta$  when looking up,  $30\Delta$  when looking straight ahead and  $50\Delta$  when looking down. In the primary (horizontal) position the exotropia measured  $30\Delta$  for 20 feet and 13 inches. There was overaction of each superior oblique muscle, being greater in the left eye (fig 7a, b, c). There was no detectable weakness of either inferior rectus or of either inferior



Fig 7 (case 3) —Exotropia with overaction of each superior oblique muscle

(a) Both eyes looking to the right. Note that the left eye is directed downward, owing to overaction of the left superior oblique muscle.

(b) Both eyes looking straight ahead and slightly up. Note that the right eye is higher than the left, owing to the greater overaction of the left superior oblique muscle.

(c) Both eyes looking to the left. Note that the right eye is directed downward, owing to overaction of the right superior oblique muscle.

(d-f) Eyes eighteen months after tenotomy of both superior oblique muscles on the nasal side of the superior rectus muscles, recession of the left external rectus muscle and resection of the left internal rectus muscle.

(d) Both eyes looking to the right after operation. Note the greater downward deviation of the left eye than shown in a, taken before operation. This is due to tenotomy of the right superior oblique without adequate tenotomy of the left superior oblique muscle.

(e) Both eyes looking straight ahead. Compare with b, and note the increased right hypertropia, owing to overaction of the left superior oblique muscle.

(f) Both eyes looking to the left. Compare with c, and note the decrease in overaction of the right superior oblique muscle.

oblique muscle Miss Elizabeth K. Stark found an exotropia of 30 to 40  $\Delta$  on the synoptophore and an exotropia of 40  $\Delta$  for 20 feet and 55  $\Delta$  for 13 inches with prisms. In May 1944 the left external rectus was recessed and the left internal rectus resected and both superior oblique muscles were tenotomized on the nasal side of the superior rectus muscles. The tendon of the right superior oblique muscle was easily identified and tenotomized, but that of the left was not well visualized and there was some doubt as to whether it was completely severed. One month after the operation the horizontal deviation was well corrected in the primary position, and there was no overaction of the right superior oblique muscle. However, there was a strong residual overaction of the left superior oblique muscle, especially with eyes directed to the right and with eyes directed down and to the right. One and one-half years after the operation there was a residual exotropia of 15  $\Delta$ , with a right hypertropia of 20  $\Delta$  for 20 feet. When the eyes were rotated to the right, while looking at a light at 20 feet, the exotropia decreased to 10  $\Delta$ , but the right hypertropia increased to 25  $\Delta$ . At 20 feet there was an exotropia of 15  $\Delta$  but no hypertropia when both eyes were directed to the left. For 13 inches there were a residual right hypertropia of 25  $\Delta$  with eyes directed to the right (fig 7d), a right hypertropia of 15  $\Delta$  with eyes in the primary position (fig 7e) and only 2  $\Delta$  of right hypertropia with eyes directed to the left (fig 7f).

For 13 inches the complete measurements were as follows

Eyes up and right	XT' 3 $\Delta$	RHT' 17 $\Delta$
Eyes straight to the right	XT' 7 $\Delta$	RHT' 25 $\Delta$ (fig 7d)
Eyes down and right	XT' 18 $\Delta$	RHT' 30 $\Delta$
Eyes straight ahead	XT' 18 $\Delta$	RHT' 15 $\Delta$ (fig 7e)
Eyes up and left	No X'	RHT' 2 $\Delta$
Eyes straight to the left	XT' 7 $\Delta$	RHT' 2 $\Delta$ (fig 7f)
Eyes down and left	XT' 25 $\Delta$	RHT' 4 $\Delta$

*Comment*—It should be noted in this case that the left hypertropia, due to overaction of the right superior oblique muscle, was practically cured by the operation (compare c and f, fig 7). However, the right hypertropia, due to overaction of the left superior oblique muscle, was actually greater after the operation (compare a and d, fig 7). The increased overaction of the left superior oblique was due to tenotomy of the right superior oblique muscle, the tendon of the left superior oblique having been missed at the time of operation. It is well known that tenotomy of one inferior oblique muscle in patients with overaction of both inferior oblique muscles will result in an apparently greater overaction in the nontenotomized inferior oblique muscle after operation. The same increase in the vertical imbalance develops post-operatively in cases with bilateral overaction of the superior oblique muscle when only one superior oblique is tenotomized.

This case demonstrates that the tendon of the superior oblique muscle should be positively identified before tenotomy is attempted, else no effect may be obtained. No harm can result from passing the muscle hook into the wound a second time to make sure the tendon has been completely severed. In cases in which the superior oblique of one eye is

more overactive than that of the other, the operation must be graded so that one superior oblique muscle is weakened more than the other

CASE 4—E L, a youth aged 18, stated that his eyes had been turned out since he was a baby. His birth was by forceps delivery. He had worn glasses since 4 years of age. His general health was good. Vision was 20/15 in the right eye with a -2.75 D sphere and 20/15 in the left eye with a -2.25 D sphere. Except for the myopia and the anomaly of the extraocular muscles, his eyes were normal. Abduction and adduction were good. The convergence near point was remote and could not be measured. No weakness was noted in either the inferior rectus or the inferior oblique muscles. For 20 feet and 13 inches he had a variable exotropia of 50 to 65  $\Delta$ , depending on the direction of gaze, complicated by overaction of each superior oblique muscle (fig 8*a, b* and *c*). With the right eye fixing the left eye moved up under cover, and with the left eye fixing the right eye moved up under



Fig 8 (case 4) —Exotropia with overaction of each superior oblique muscle

(*a*) Both eyes looking to the right and downward. Note the pronounced downward deviation of the left eye, owing to overaction of the left superior oblique muscle.

(*b*) Both eyes looking straight ahead, with the right eye fixing. Note the upward deviation of the left eye. With the left eye fixing, the right eye deviated upward.

(*c*) Both eyes looking to the left and downward. Note the pronounced downward deviation in the right eye, owing to overaction of the right superior oblique muscle.

(*d-f*) Eyes six months after operation.

(*d*) Both eyes looking to the right. Compare with *a*, and note the great improvement in the vertical deviation, owing to tenotomy of the left superior oblique.

(*e*) Both eyes looking straight ahead. Compare with *b*.

(*f*) Both eyes looking to the left. Compare with *c*, and note the decrease in the vertical deviation, owing to tenotomy of the right superior oblique muscle.

cover Measurements of the imbalance of the extraocular muscles in the different directions of gaze were as follows

Eyes up and right	XT' 50 $\Delta$	No HT'
Eyes straight to the right	XT' 55 $\Delta$	RHT' 10 $\Delta$
Eyes down and right	XT' 50 $\Delta$	RHT' 25 $\Delta$ (fig 8 a)
Eyes straight up	XT' 60 $\Delta$	No HT'
Eyes straight ahead	XT' 65 $\Delta$	Double HT' (fig 8 b)
Eyes straight down	XT' 65 $\Delta$	RHT' 8 $\Delta$
Eyes up and left	XT' 50 $\Delta$	No HT'
Eyes straight to the left	XT' 50 $\Delta$	LHT' 5 $\Delta$
Eyes down and left	XT' 60 $\Delta$	LHT' 25 $\Delta$ (fig 8 c)

In September 1943, both internal rectus muscles were resected, both external rectus muscles recessed and both superior oblique muscles tenotomized. The right superior oblique was tenotomized lateral to the superior rectus muscle, and the left superior oblique, medial to the superior rectus muscle. The patient made an excellent postoperative recovery. Six months after the operation the eyes were cosmetically straight for both 20 feet and 13 inches (fig 8e). With the eyes in the primary position for near vision there was a slight residual double hypertropia in the cover test. In rotation of his eyes to the right (fig 8d) there was still present a slight right hypertropia, of about 5  $\Delta$ , due to a residual overaction of the left superior oblique muscle. In rotation of his eyes to the left, there was still present a slight left hypertropia of about 5  $\Delta$  (fig 8f), due to residual overaction of the right superior oblique muscle.

*Comment*—This patient obtained an excellent postoperative result. The exotropia, as well as the right hypertropia, was well corrected in eyes right (compare *a* and *d* in figure 8) and the left hypertropia in eyes left (compare *c* and *f* in figure 8). In this case, there was no detectable difference in the effect of the two tenotomies, the right superior oblique muscle having been tenotomized at its insertion lateral to, and the left superior oblique muscle medial to, the superior rectus, both under Tenon's capsule. In general, it can be said that tenotomy of the superior oblique lateral to the superior rectus (i.e., at its insertion to the globe) is less certain in its effect than tenotomy on the nasal side of the superior rectus.

The prism measurements before and after operation were carefully taken in the six cardinal directions of gaze. Even though the patient was most cooperative, it was difficult to measure the horizontal and vertical deviations to within less than 5  $\Delta$  of the true error present because of the tendency of these measurements to vary with the direction of the eyes, the position of the prisms, the patient's attention and other mechanical and physiologic factors. In all cases the measurements were carefully and conscientiously taken, but some allowance must be made for human error on the part of the patient and the physician.

CASE 5—Mrs H. R., aged 25, complained of eyestrain, headaches above the eyes and confusion of print when reading. At times she saw double when looking to the right or to the left. She had tried several pairs of glasses and fusion



Fig 9 (case 5) —Overaction of each superior oblique muscle before operation (a-h) and after (d-e) the last tenectomy

(a) Both eyes looking up and to the right Note the right hypertropia

(b) Both eyes looking up and to the left Note the left hypertropia

(c) Both eyes looking to the right Note the right hypertropia, owing to overaction of the left superior oblique muscle

(d) Both eyes looking to the left Note the left hypertropia, owing to overaction of the right superior oblique muscle

(e) Both eyes looking to the right and down Note the right hypertropia, owing to overaction of the left superior oblique muscle

(f) Both eyes looking to the left and down Note the left hypertropia, owing to overaction of the right superior oblique muscle

*g**h**i**j**k**l*

(*g*) Both eyes directed up and to the right Compare with *a*

(*h*) Both eyes directed up and to the left Compare with *b*

(*i*) Both eyes directed to the right Compare with *c*, and note the higher position of the left eye in *i*

(*j*) Both eyes directed to the left Compare with *d*, and note the higher position of the right eye in *j*

(*k*) Both eyes directed to the right and downward Compare with *e*, and note the higher and improved position of the left eye in *k*

(*l*) Both eyes directed downward and to the left Compare with *f*, and note the higher and improved position of the right eye in *l*

exercises, without relief Examination showed defective depth perception, a moderate amount of astigmatism and double hypertropia, due to overaction of each superior oblique muscle Refraction with homatropine-paredrine cycloplegia showed the following error

Right eye +0.50 D sph  $\ominus$  +1.50 D cyl, axis 110, vision 20/20  
Left eye +1.50 D cyl, axis 80, vision 20/20

With the prescription in place, the near point of accommodation was 12 cm for each eye For 20 feet the patient had 1  $\Delta$  of left hyperphoria and 3  $\Delta$  of esophoria Her near point of convergence was normal

This patient had two operations on the tendon of each superior oblique muscle before she was comfortable Before the first operation, there was right hypertropia of 12  $\Delta$  in eyes directed to the right, left hypertropia of 20  $\Delta$  in eyes directed to the left and double hypertropia in the primary position for distance For 13 inches in the different directions of gaze, the measurements were

Eyes up and right	X'T' 5 $\Delta$	RHT' 10 $\Delta$ (fig 9 a)
Eyes right	No X'	RHT' 12 $\Delta$ (fig 9 c)
Eyes down and right	X' 15 $\Delta$	RHT' 15 $\Delta$ (fig 9 e)
Eyes up and left	ST' 5 $\Delta$	LHT' 10 $\Delta$ (fig 9 b)
Eyes left	ST' 7 $\Delta$	LHT' 20 $\Delta$ (fig 9 d)
Eyes down and left	X'T' 10 $\Delta$	LHT' 20 $\Delta$ (fig 9 f)

The first operation was done in August 1944 on the tendons of both superior oblique muscles with local anesthesia through a conjunctival incision The tendon of each superior oblique muscle was identified on the nasal side of the superior rectus and severed with as little trauma as possible In view of the undercorrection which resulted, it would have been wiser to remove a part of each tendon instead of merely incising it

Six weeks after operation, the patient presented 1  $\Delta$  of right hyperphoria for 20 feet and 4  $\Delta$  of esophoria with the Maddox rod For near vision measurements for the extraocular muscle were

Eyes up and right	RHT' 5 $\Delta$ (a reduction in RHT' of 5 $\Delta$ )
Eyes right	RHT' 16 $\Delta$ (an increase in RHT' of 4 $\Delta$ ) (fig 10 a)
Eyes down and right	RHT' 20 $\Delta$ (an increase in RHT' of 5 $\Delta$ )
Eyes up and left	LHT' 10 $\Delta$ (no change in H'T')
Eyes left	LHT' 10 $\Delta$ (a reduction in LHT' of 10 $\Delta$ ) (fig 10 c)
Eyes down and left	LHT' 7 $\Delta$ (a reduction in LHT' of 13 $\Delta$ )

These measurements and the pictures taken after operation (fig 10 a and c) show that each superior oblique muscle was still overactive, the overaction of the left superior oblique in eyes directed to the right being definitely greater than the overaction of the right superior oblique in eyes directed to the left Therefore, the left superior oblique muscle was tenectomized, with use of local anesthesia, six weeks after the first operation An incision was made through the conjunctiva in the superior nasal quadrant Scar tissue from the previous operation was encountered, but the sheath of the reflected tendon was easily picked up and identified A hemostat was applied to the tendon, and the sheath and the tissue in the clamp were excised by cutting on either side of it After this, the patient, whose eyes were uncovered, was asked to look to the right Some overaction of the left superior oblique muscle persisted Therefore, the hook was passed deeper into the wound and another bite of the sheath of the tendon of the superior oblique

muscle removed. After this maneuver, the overaction of the left superior oblique was reduced to what appeared to be less than  $5\Delta$ .

Four days after the operation the overaction of the left superior oblique muscle had been changed to slight paresis in extreme rotation of the eyes down and to the right. This paresis later disappeared entirely. At that time the right hyper-



Fig 10 (case 5) —(a-b) Eyes six weeks after the first operation on the left superior oblique tendon

(a) Both eyes directed to the right. Compare with figure 9c, and note that the patient still has a pronounced right hypertropia, owing to residual overaction of the left superior oblique muscle.

(b) Both eyes looking straight ahead.

(c) Both eyes looking to the left, six weeks after the first operation on the right superior oblique tendon. As compared with figure 9c, there appears to be less overaction of the right superior oblique muscle after operation.

(d-f) One month after the second operation on the left superior oblique tendon.

(d) Both eyes directed to the right. Note that the right hypertropia shown in a has been greatly reduced.

(e) Both eyes looking straight ahead.

(f) Both eyes looking to the left. Compare with c, and note that the left hypertropia shown in f is greater than before the second operation.

(g-i) One month after the second operation on the right superior oblique tendon.

(g) Both eyes looking to the right.

(h) Both eyes looking straight ahead.

(i) Both eyes looking to the left. Compare with f and note the great improvement in the overaction of the right superior oblique muscle.



tropia in the up and down positions of eyes directed to the right was well corrected, but the left hypertropia in eyes directed to the left seemed greater than before the second operation. One month later the measurements were

Eyes up and right	RH	5 $\Delta$ (no change in RHT')
Eyes right	RH'	5 $\Delta$ (a reduction in RHT' of 11 $\Delta$ ) (fig. 10 d)
Eyes down and right	LH'	5 $\Delta$ (a reduction in RHT' of 15 $\Delta$ )
Eyes up and left	LHT'	15 $\Delta$ (an increase of LHT' of 5 $\Delta$ )
Eyes left	LHT'	18 $\Delta$ (an increase of LHT' of 8 $\Delta$ ) (fig. 10 f c)
Eyes down and left	LHT'	20 $\Delta$ (an increase of LHT' of 13 $\Delta$ )

Diplopia fields showed that the patient was able to fuse in all positions of the binocular fields except in eyes up and left, eyes left, eyes down and left and in eyes straight down. The greatest separation of images was in eyes down and left, i. e., in the field of action of the right superior oblique muscle.

The right superior oblique muscle was tenectomized ten weeks after the first operation. Again, there were scar tissue and slight difficulty in picking up the tendon of the superior oblique muscle. A hemostat was applied to the tendon and its sheath and a part of both excised by cutting on either side of the hemostat. After this, the overaction of the right superior oblique muscle was relieved.

One month after the last operation measurements of muscle balance showed

Eyes up and right	N' 3 $\Delta$	RHT' 3 $\Delta$
Eyes right	No N'	RH' 3 $\Delta$ (fig. 10 g)
Eyes down and right	No N'	No H'
Eyes straight		Orthophoria (fig. 10 h)
Eyes up and left	S' 5 $\Delta$	LHT' trace
Eyes left	S' 5 $\Delta$	LHT' trace (fig. 10 i)
Eyes down and left	S' 5 $\Delta$	LHT' trace

The astigmatic axis had changed from 110 to 120 degrees in the right eye and from 80 to 72 degrees in the left eye. With her glasses she had 20/15—2 vision in each eye, an esophoria of 5  $\Delta$  and a left hyperphoria of 1  $\Delta$  for 20 feet with the Maddox rod. Her diplopia fields were normal in all directions of gaze except in extreme rotation up and to the left, where there was a slight separation of the two images with a red glass over one eye and a green glass over the other. Without colored glasses, she had no diplopia in any of the fields. When last seen, six and one-half months after the last operation, she stated that she had had no more headaches or diplopia and that she could read as much as she liked without symptoms of eyestrain. She volunteered the information that her "eyes felt wonderful since the operation." Her final check-up showed

Eyes up and right	RH' 2 $\Delta$	(fig. 9 a)
Eyes right	RH' 2 $\Delta$	(fig. 9 i)
Eyes down and right	RH' 3 $\Delta$	S' 4 $\Delta$ (fig. 9 k)
Eyes up and left	No H'	N' 2 $\Delta$ (fig. 9 h)
Eyes left	RH' 4 $\Delta$	S' 3 $\Delta$ (fig. 9 j)
Eyes down and left	No H	(fig. 9 l)

In the primary position for 20 feet with the Maddox rod, she had left hyperphoria of 1  $\Delta$  and esophoria of 4 to 6  $\Delta$ , and for 13 inches, orthophoria. With the Maddox rod there seemed to be 5 degrees of outward cyclophoria in the right eye but no cyclophoria in the left eye. Her near point of convergence was 60 mm. With the Keystone fusion card no DB33781, she had 20/20 fusion. Insignificant conjunctival scars were noted under the upper lids.

*Comment*—The excellent cosmetic and functional result in this case can be seen by comparing pictures taken in the six cardinal directions of gaze before and after operation (fig 9). One should compare especially the right hypertropia and exotropia present before operation, when the eyes were directed down and to the right (fig 9e), with the final postoperative result in the same position (fig 9k). Also, the pronounced left hypertropia present when the eyes were rotated down and to the left before operation (fig 9f) should be compared with the final postoperative result in this position (fig 9l).

Two items in this case require further comment, namely the need of more than one operation and the apparent increase in overaction of one superior oblique muscle after operation on the opposite superior oblique muscle. The need of two operations on each superior oblique muscle must be attributed to lack of experience and to timidity. Because this patient had binocular single vision with some fusion, the surgeon was anxious not to produce a troublesome postoperative diplopia. The experience gained in this and in subsequent cases would tend to indicate that when the vertical deviation is more than  $10\Delta$  a part of the tendon of the superior oblique muscle must be removed to produce adequate correction.

After the first operation on the tendon of each superior oblique, an apparent increase in overaction of the left superior oblique muscle developed. When the left superior oblique muscle was tenotomized a second time, an apparent increase in the overaction of the right superior oblique muscle developed. This is best explained by recalling that in cases of bilateral overaction of the inferior oblique muscle tenotomy of one inferior oblique muscle causes an apparent increase in the overaction of the opposite inferior oblique muscle. The same phenomenon would develop if one superior oblique muscle was tenotomized more completely than the other. Therefore, to get a satisfactory result in a case of bilateral overaction of the superior oblique muscle, the operation must be graded to fit the amount of overaction present. If the vertical deviation is equal, an equal tenotomy or tenectomy on the two muscles is indicated. If unequal, more tendon must be removed from the more overactive superior oblique muscle.

As previously stated, some surgeons recommend correction of the vertical deviation before attempting correction of the horizontal deviation in cases of combined vertical and horizontal squint, contending that this procedure obviates the need of a second operation to correct the horizontal deviation. This procedure worked out well in this case, as can be seen by comparing the combined horizontal and vertical deviation

present before operation (fig 9e and f) with that present after the superior oblique muscles had been tenectomized (fig 9k and l)

CASE 6—L R, a Negro aged 21, came to the Vanderbilt Clinic to have his right eye straightened. He stated that vision in the right eye had been poor all his life, owing to the presence of a "white spot" over the pupil since he was a baby, and that the right eye had been crossed for years. Examination showed vision equal to counting fingers at 3 feet (90 cm) in the right eye and 20/20 in the left eye. The poor vision in the right eye was due to a dense, white corneal leukoma with incarceration of the iris. Because of the amblyopia present in the right eye, the esotropia present could not be carefully measured with the cover test. With prisms held before the fixing eye, the esotropia was estimated to be  $30\Delta$  for distant and near vision. A strong overaction of the right superior oblique was present, which produced a left hypertropia of about  $20\Delta$  in eyes left (fig 11). The patient was sent to the hospital, where the corneal leukoma was tattooed, the right superior oblique muscle tenotomized through the conjunctiva on the nasal side of the superior rectus muscle and the right internal rectus muscle recessed. On his leaving the hospital, ten days later, the right



Fig 11 (case 6)—(A) Both eyes looking straight ahead, with the left eye fixing. Note the corneal scar, the slight esotropia and the right hypertropia in the right eye. (B) Both eyes looking to the left, with the left eye fixing. Note the marked downshoot of the right eye, owing to spasm of the right superior oblique muscle.

eye was cosmetically straight, with slight residual overaction of the right superior oblique muscle. The patient did not return to the clinic for follow-up care.

*Comment*—In view of the undercorrection obtained in this case with simple tenotomy, it would have been better to excise 5 mm of the tendon. This was not done because of the fear of producing an overeffect.

CASE 7—N C, a girl aged 9, came to the Vanderbilt Clinic in 1943 complaining of a crossed left eye of several years' duration. Examination showed vision of 20/30 in the right eye and 20/50 in the left, improved with glasses to 20/20—2 in the right eye and to 20/30 in the left. An exotropia of  $55\Delta$  for distant and near vision was noted, complicated by a right hypertropia of  $7\Delta$  for near vision. There was no increase of the hypertropia in the six cardinal directions of gaze. Otherwise, the eyes were essentially normal.

In July 1943 a 4 mm recession of the internal rectus and a 10 mm resection of the external rectus muscle were done. The patient made an uncomplicated

postoperative recovery When she was seen in January 1946, the cosmetic result was excellent in the primary position, but the cover test revealed right hypertropia in all positions of gaze as recorded below

Eyes up and right	NT' 16 $\Delta$	RHT' 27 $\Delta$
Eyes right	NT' 10 $\Delta$	RHT' 22 $\Delta$
Eyes down and right	NT' 10 $\Delta$	RHT' 18 $\Delta$
Eyes straight	ST' 5 $\Delta$	RHT' 12 $\Delta$
Eyes up and left	NT' 16 $\Delta$	RHT' 18 $\Delta$
Eyes left	NT' 0	RHT' 10 $\Delta$
Eyes down and left	NT' 0	RHT' 10 $\Delta$

The right hypertropia in eyes directed up and to the right was due to acquired weakness of the left inferior oblique muscle. Since this weakness was not present before the operation two and one-half years before, it seemed that the inferior oblique must have been injured during the operation on the external rectus, when the latter was being freed from Tenon's capsule. Because of the close association of these two muscles on the lateral surface of the globe, the inferior oblique is easily injured unwittingly. The right hypertropia in the right lower corner was due to overaction of the left superior oblique, secondary to weakness of the left inferior oblique. The right hypertropia in the left upper corner was thought to be due to overaction of the right inferior oblique.

To correct the vertical deviation, three operations were considered, namely, (1) tenectomy of the left superior oblique, (2) advancement of the left inferior oblique and (3) myectomy of the right inferior oblique muscle. It seemed that the safest procedure was to do these operations at different times. Therefore, on Jan 17, 1946, a 5 mm tenectomy of the left superior oblique was done, with the patient under general anesthesia.

One week after the operation the deviation measured

Eyes up and right	XT' 12 $\Delta$	RHT' 24 $\Delta$
Eyes right	XT' 10 $\Delta$	RHT' 12 $\Delta$
Eyes down and right	XT' 0.5 $\Delta$	RHT' 0.5 $\Delta$
Eyes straight		RHT' 0.5 $\Delta$
Eyes up and left	XT' trace	RHT' 14 $\Delta$
Eyes left	XT' trace	RHT' 5 $\Delta$
Eyes down and left	XT' trace	RHT' 8 $\Delta$

*Comment*—The operation on the left superior oblique muscle reduced the right hypertropia in eyes directed down and to the right from 18 to 5  $\Delta$  (sometimes 0). Therefore, the tenectomy of the left superior oblique did everything that could have been hoped for in reducing the right hypertropia in eyes directed down and to the right. A shortening of the left inferior oblique is contemplated at some later date. When the patient was last seen, six months after the operation, the vertical deviation was essentially the same as the measurements taken one week after operation.

CASE 8—C L, a girl aged 3 years, had a crossed right eye of one year's duration. There was no history of esotropia in the parents or grandparents, birth was by normal delivery, and the general health was good.

Examination showed normal eyes except for an esotropia of 40  $\Delta$  for distance and 50  $\Delta$  for near vision, associated with a left hypertropia of 20  $\Delta$ , due to a pronounced overaction of the left inferior oblique muscle. Examination with atropine cycloplegia showed a small amount of compound hyperopic astigmatism of each eye. The child was too young to cooperate in recording the visual acuity, but it was noted that the left eye was the fixing eye. In August 1943 the child was sent to the hospital to have a recession of the right internal rectus muscle, a resection of the right external rectus muscle and a myectomy of the overactive left inferior oblique. By mistake, the recession and resection were done on the left eye, and the normal right inferior oblique was myectomized.

After the operation, the esotropia was fairly well corrected, but the left hypertropia, due to overaction of the nonmyectomized left inferior oblique, was unchanged. In addition to an upshoot of the left eye when both eyes were directed to the right (overaction of the left inferior oblique muscle), there was now a right hypotropia (left hypertropia) in eyes directed up and to the left, owing to weakness of the myectomized right inferior oblique. Associated with the weakness of the right inferior oblique was an overaction of the right superior oblique, which increased the left hypertropia in eyes directed down and to the left. The condition did not change in the following two years. In October 1945 the following operation was done: (1) myectomy of the left inferior oblique muscle, (2) tenectomy of the right superior oblique muscle and (3) resection of the right external rectus muscle. The measurements of squint before the last operation were

Eyes up and right	ST' 15 $\Delta$	LHT' 25 $\Delta$
Eyes right	ST' 25 $\Delta$	LHT' 20 $\Delta$
Eyes down and right	ST' 15 $\Delta$	LHT' 18 $\Delta$
Eyes straight	ST' 30 $\Delta$	LHT' 20 $\Delta$
Eyes up and left	ST' 25 $\Delta$	LHT' 20 $\Delta$
Eyes left	ST' 25 $\Delta$	LHT' 15 $\Delta$
Eyes down and left	ST' 20 $\Delta$	LHT' 25 $\Delta$

Five months after operation there was still present a slight residual overaction of the left inferior oblique muscle, which produced left hypertropia in eyes directed to the right. The left hypertropia in eyes directed to the left, due to weakness of the right inferior oblique and spasm of the right superior oblique, was well corrected. The measurements were

Eyes up and right	ST' 5 $\Delta$	LHT' 5 $\Delta$
Eyes right	ST' 0 $\Delta$	LHT' 5 $\Delta$
Eyes down and right	ST' 0 $\Delta$	LHT' 5 $\Delta$
Eyes straight	ST' 0 $\Delta$	LHT' 8 $\Delta$
Eyes up and left	ST' 10 $\Delta$	LHT' 0 $\Delta$
Eyes left	ST' 5 $\Delta$	LHT' 0 $\Delta$
Eyes down and left	ST' 15 $\Delta$	LHT' 0 $\Delta$

Pictures before and after operation were attempted several times, but none was successfully taken because of the child's poor cooperation.

*Comment*—The mistake of myectomizing the normal right inferior oblique instead of the overactive left inferior oblique muscle might happen to any one. Fortunately, the error was corrected by weakening the direct antagonist of the right inferior oblique, i. e., the right superior oblique.

CASE 9—Master N P, aged  $4\frac{1}{2}$ , had an exotropia of 30 to 50  $\Delta$ , associated with overaction of each superior oblique muscle. In May 1944, the left external rectus muscle was recessed, the left internal rectus was resected and both superior oblique muscles were tenotomized on the nasal border of the superior rectus. After the operation, residual exotropia and right hypertropia persisted, the measurements with prisms being as follows:

Eyes up and right	$\Delta T' 3 \Delta$	RHT' 17 $\Delta$
Eyes right	$\Delta T' 10 \Delta$	RHT' 25 $\Delta$ (fig 12 a)
Eyes down and right	$\Delta T' 18 \Delta$	RHT' 30 $\Delta$
Eyes straight	$\Delta T' 15 \Delta$	RHT' 20 $\Delta$ (fig 12 b)
Eyes up and left	$\Delta T' 0 \Delta$	RHT' 2 $\Delta$
Eyes left	$\Delta T' 7 \Delta$	RHT' 2 $\Delta$ (fig 12 c)
Eyes down and left	$\Delta T' 25 \Delta$	RHT' 4 $\Delta$

This operation corrected most of the exotropia and most of the left hypertropia when the eyes were directed to the left, but the right hypertropia in eyes directed to the right, due to overaction of the left superior oblique, remained essentially the same. It was therefore decided to tenectomize the left superior oblique and, at the same time, to resect the left internal rectus. The patient made an excellent postoperative recovery. Two weeks after the second operation there was no hypertropia with the cover test in eyes directed to the right, and there was no clinically discernible weakness of the left superior oblique. The left upper lid drooped a little, owing, presumably, to residual edema (fig 12 a).

Two and one-half months after the operation the overaction of the left superior oblique muscle was greatly reduced, as shown by the following measurements with prisms:

Eyes up and right	$\Delta T'$ trace	HT' 0 $\Delta$
Eyes right	$\Delta T'$ trace	HT' 0 $\Delta$ (fig 12 d)
Eyes down and right	$\Delta T'$ trace	LHT' trace
Eyes straight	$\Delta T' 0 \Delta$	HT' 0 $\Delta$ (fig 12 e)
Eyes up and left	$\Delta T'$ trace	HT' 0 $\Delta$
Eyes left	$\Delta T'$ trace	LHT' trace (fig 12 f)
Eyes down and left	$\Delta T'$ trace	LHT' 5 $\Delta$

*Comment*—In this case a 5 mm tenectomy of the left superior oblique reduced the right hypertropia in eyes down and right from 30  $\Delta$  to a trace of left hypertropia. A questionable weakness of the left superior oblique of less than 5  $\Delta$  was noted in extreme rotation of the eyes to the right lower field. It was impossible to measure accurately this slight deviation because it did not become discernible until the left eye was carried so far down that it was hidden from view by the nose.

CASE 10—M M, a girl aged 15, came to the Vanderbilt Clinic in January 1939 with 6 mm of congenital ptosis of the left upper lid. Examination showed vision of 20/20 in each eye with orthophoria for distance and near vision. No weakness was noted in either superior rectus muscle. On May 29, 1939 a resection of the left levator palpebrae muscle was done, with slight improvement in the amount of ptosis present. On Dec 4, 1939 a Parinaud-Young operation for ptosis was done through a conjunctival incision. After this procedure, the ptosis was slightly improved, but a notch in the upper lid formed. On July 8, 1940 the upper border of the tarsus was again sutured to the superior rectus muscle through a conjunctival incision. After the third operation the ptosis was well corrected, but the patient

complained of vertical diplopia. Examination showed pronounced weakness of the left superior rectus, sufficient to produce a right hypertropia of 20 to 30  $\Delta$  when looking up and to the left. On Dec 7, 1945 the patient still complained of diplopia and the prism measurements were

Eyes up and right	XT' 22 $\Delta$	RHT' 20 $\Delta$ (fig 13 a)
Eyes right	XT' 19 $\Delta$	RHT' 24 $\Delta$ (fig 13 d)
Eyes down and right	XT' 18 $\Delta$	RHT' 21 $\Delta$ (fig 13 g)
Eyes straight	XT' 11 $\Delta$	RHT' 3 $\Delta$ (fig 13 e)
Eyes up and left	XT' 15 $\Delta$	RHT' 18 $\Delta$ (fig 13 c)
Eyes left	XT' 4 $\Delta$	RHT' 2 $\Delta$ (fig 13 f)
Eyes down and left	XT' 7 $\Delta$	RHT' 2 $\Delta$ (fig 13 i)

A diagnosis of weakness of the left superior rectus and the left inferior oblique muscle, associated with overaction of the left superior oblique, was made. On Dec 18, 1945 an incision was made in the upper nasal quadrant of the conjunctiva of the left eye and Tenon's capsule undermined. Considerable scar tissue from the three previous operations was encountered, and the tendon of the superior oblique was picked up and tenotomized with considerable difficulty.



Fig 12 (case 9)—(a-c) Eyes as in figure 7 (d-f)

(a) Both eyes directed to the right, with the right eye fixing. Note the large amount of left hypotropia present because of overaction of the left superior oblique muscle.

(b) Both eyes looking straight ahead. Note the ptosis and the hypotropia of the left eye.

(c) Both eyes directed to the left.

(d-f) Eyes two and one-half months after tenectomy of the left superior oblique muscle and resection of the left internal rectus muscle.

(d) Both eyes directed to the right. Note the pronounced improvement in the left hypotropia after operation.

(e) Both eyes looking straight ahead. Note the residual ptosis and absence of left hypotropia.

(f) Both eyes directed to the left. Note that in this case tenectomy of the left superior oblique did not affect the muscle balance in this position.

The operation on the left superior oblique muscle greatly reduced the vertical deviation (fig 13) in the entire lower field, so that the patient no longer had spontaneous diplopia here. However, diplopia could be induced by covering one eye with a red glass. Diplopia fields showed a considerable reduction of the vertical diplopia in the field of action of the once overactive left superior oblique muscle (fig 14).

*Comment*—The diplopia and weakness of the elevator muscles (superior rectus and inferior oblique) of the left eye in this case developed after the operation for relief of ptosis and was due most likely to the weight of the upper lid. The patient had fusion only in a small area in the field of action of the left inferior rectus muscle. Therefore, operation to cure the diplopia should avoid this muscle. Because the lower fields of vision are more important in everyday life and because she had diplopia in the field of action of the left superior oblique muscle, weakening of this muscle was indicated. The postoperative result was gratifying.

CASE 11—Mrs. A. L., aged 57, had had a crossed right eye since infancy. Vision in the right eye had been poor all her life and could not be improved beyond 20/200 with glasses. Vision in the left eye was 20/20 with a correction for weak compound hyperopia. The patient had exotropia for distance and near vision associated with an overaction of each superior oblique muscle. For 20 feet the deviation measured 40  $\Delta$  of exotropia and 10  $\Delta$  of left hypertropia. For 16 inches the exotropia was 50  $\Delta$  and the left hypertropia 10  $\Delta$ . The prism measurements in the different directions of gaze were

Eyes up and right	XT' 55 $\Delta$	RHT' trace
Eyes right	XT' 50 $\Delta$	RHT' 8 $\Delta$
Eyes down and right	XT' 45 $\Delta$	RHT' 15 $\Delta$
Eyes straight	XT' 50 $\Delta$	LHT' 10 $\Delta$
Eyes up and left	XT' 55 $\Delta$	LHT' trace
Eyes left	XT' 50 $\Delta$	LHT' 5 $\Delta$
Eyes down and left	XT' 45 $\Delta$	LHT' 10 $\Delta$

On March 25, 1946 both superior oblique muscles were tenectomized (the left 6 to 7 mm and the right 5 mm), the right external rectus muscle was recessed 7 mm, and the right internal rectus muscle was resected 9 mm. One month after the operation the right hypertropia in eyes directed down and to the right (due to overaction of the left superior oblique muscle) was reduced from 15 to less than 5  $\Delta$ . The left hypertropia in eyes directed down and to the left (due to overaction of the right superior oblique muscle) was changed from a left hypertropia of 10  $\Delta$  before operation to a right hypertropia of 6 to 9  $\Delta$ . The right hypertropia in eyes directed down and to the left was due to an induced weakness of the right superior oblique muscle.

When last seen two months after the operation, her extraocular muscle balance in the six cardinal directions of gaze were

Eyes up and right	XT' 15 $\Delta$	LHT' 6 $\Delta$
Eyes right	XT' 0 $\Delta$	LHT' 3 $\Delta$
Eyes down and right	ST' 15 $\Delta$	LHT' 0 $\Delta$
Eyes straight ahead	XT' 15 $\Delta$	LHT' 0 $\Delta$
Eyes up and left	XT' 20 $\Delta$	HT' 0 $\Delta$
Eyes left	XT' 20 $\Delta$	LHT' 5 $\Delta$
Eyes down and left	XT' 0 $\Delta$	HT' 0 $\Delta$

For distance she had 6  $\Delta$  of exotropia and 2  $\Delta$  of left hypertropia.





(See legend on opposite page)

CASE 12—M R, a girl aged  $2\frac{1}{2}$ , had a pronounced head tilt, with the occiput on the right shoulder and with her eyes turned to the left. In this position she obviously saw single. She was an "instrument baby" and had what her physician called a premature synostosis of the cranial sutures—a congenital dysplasia of the skull. This condition produced extreme asymmetry of the face, head and orbits. The head tilt was attributed to paresis of some of the extraocular muscles, due to the distortion of the orbits.

Ocular examination showed that the child had good fixation in each eye. Careful measurement of the excursions of the extraocular muscles in the cardinal directions of gaze was virtually impossible because of the patient's age. There was present, beyond any doubt, weakness of the right superior rectus muscle with pronounced overaction of the contralateral inferior oblique muscle. This was most prominent in eyes directed up and to the right. In eyes directed up and to the left, there was moderate weakness of the right inferior oblique muscle with moderate overaction of the contralateral superior rectus muscle, especially when the right eye was used for fixation. In eyes directed down and to the left there was moderate overaction of the right superior oblique, secondary to weakness of the homolateral inferior oblique muscle. This case, therefore, was one of weakness of the elevator extraocular muscles of the right eye with secondary overaction of the left inferior oblique, left superior rectus and right superior oblique muscles.

At operation, the right superior oblique muscle was tenectomized 5 mm, and the left inferior oblique muscle was myectomized 5 to 6 mm. Nothing was done to the other extraocular muscles. Five weeks after the operation moderate overaction of the left inferior oblique and slight residual overaction of the right superior oblique muscle persisted. The elevating power of the paretic right inferior oblique muscle had been perceptibly increased by weakening the power of its direct antagonist. The head tilt was less pronounced but still present. At a later date a recession of the left inferior oblique muscle may have to be done.

Fig 13 (case 10) —(A) Both eyes directed up and to the right. Note the left hypertropia, owing to weakness of the left inferior oblique muscle. (B) Both eyes directed straight up. Note the weakness of elevation of the left eye. (C) Both eyes directed up and to the left. Note the left hypotropia, owing to weakness of the left superior rectus muscle. (D) Both eyes directed to the right. Note the left hypotropia, owing to weakness of the left inferior oblique and overaction of the left superior oblique muscle. (E) Both eyes directed straight ahead. (F) Both eyes directed to the left. (G) Both eyes directed down and to the right. Note the left hypotropia, owing to overaction of the left superior oblique. (H) Both eyes looking straight down. (I) Both eyes looking down and to the left. This was the only position of gaze in which she had single binocular vision. In all other positions she saw double. (J-P) Eyes after tenotomy of the left superior oblique muscle. (J) Both eyes directed up and to the right. Some weakness of the left inferior oblique muscle still persists. Compare with A. (K) Both eyes directed up and to the left. (L) Both eyes directed to the right. The patient did not have spontaneous diplopia in this field. Compare with D. (M) Both eyes straight ahead. Compare with E, and note that the left eye is higher in M. (N) Both eyes directed to the left. (O) Both eyes directed down and to the right. The patient still had some residual overaction of the left superior oblique (compare with G), but had no spontaneous diplopia in this position. (P) Eyes directed down and to the left.

*Comment*—In this case the overaction of the right superior oblique was secondary to weakness of its direct antagonist—the right inferior oblique muscle. Tenectomy of the right superior oblique definitely increased the elevating power of the right inferior oblique without producing a manifest weakness of the former.

CASE 13—J. B., a youth aged 16, came to the Vanderbilt Clinic in April 1946 because his eyes had been crossed since he had measles in childhood. Examination

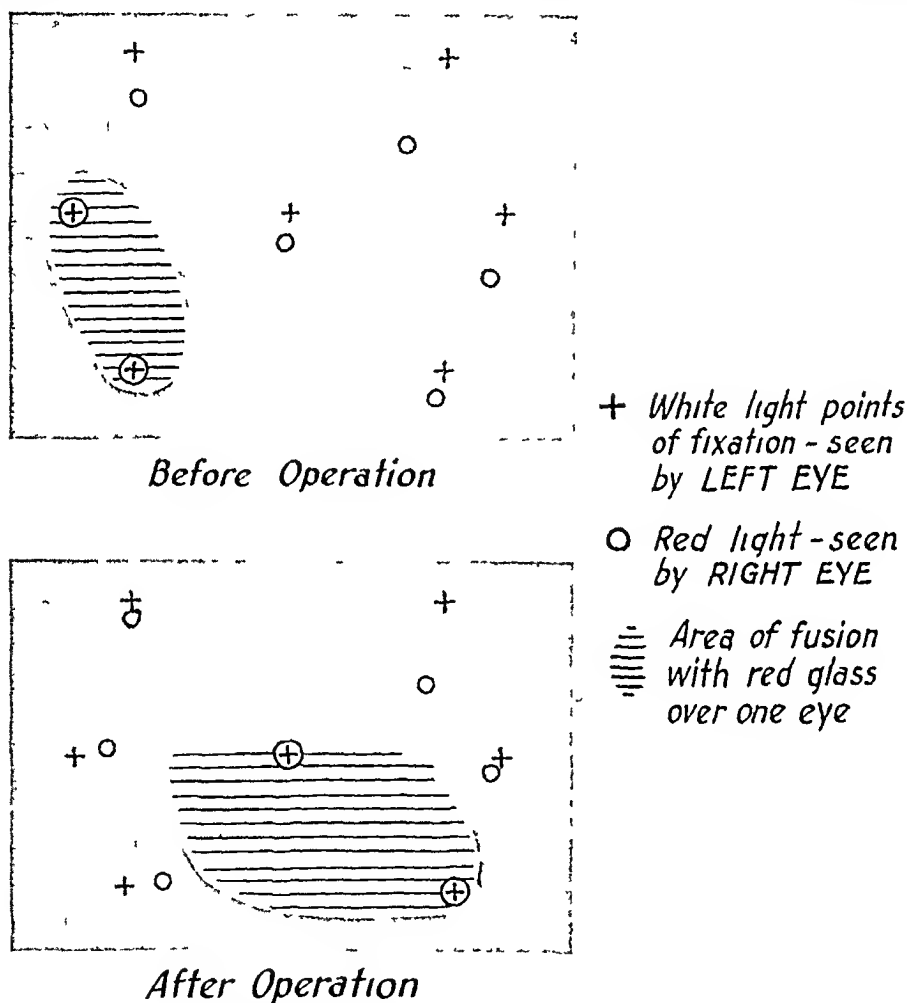


Fig. 14 (case 10)—Fields for diplopia before and after operation. A red glass was held over the right eye, the patient sat 75 cm from the tangent screen, and each reading was taken 75 cm from the central point of fixation. This rotated the eyes 45 degrees from the primary position into the six cardinal directions of gaze. Note that the diplopia was less in the right lower field (field of action of the left superior oblique) and that the patient had fusion over a wider area after operation.

showed vision to be 20/20 in the right eye and 20/40 in the left eye, which was improved to 20/20 and 20/30 respectively with glasses. For distance his deviation measured 21  $\Delta$  of esotropia and 22  $\Delta$  of left hypertropia, and for near vision the

near point of convergence was almost to the point of his nose (50 mm) His fundi were normal No ptosis was present Prism measurements for near vision were as follows

Eyes up and right	ST' 16 $\Delta$	LHT' 30 $\Delta$
Eyes down and right	ST' 25 $\Delta$	LHT' 40 $\Delta$
Eyes straight	ST' 21 $\Delta$	LHT' 30 $\Delta$
Eyes up and left	ST' 16 $\Delta$	LHT' 18 $\Delta$
Eyes down and left	ST' 25 $\Delta$	LHT' 30 $\Delta$

In eyes directed up and to the right there was weakness of the right superior rectus muscle with overaction of the contralateral inferior oblique muscle In eyes directed up and to the left there was definite weakness of the right inferior oblique muscle with overaction of the left superior rectus, especially with the right eye fixating the muscle light In eyes directed down and to the left there was pronounced overaction of the right superior oblique muscle In eyes directed down and to the right there was pronounced left hypertropia, due to contraction of the left inferior rectus or to weakness of the left superior oblique muscle In short, this patient presented the findings characteristic of weakness of the elevator extraocular muscles (superior rectus and inferior oblique) of the right eye with overaction of the associated yoke and direct antagonist muscles

On April 4, 1946 the right superior oblique muscle was tenectomized 5 mm At the same time, the left internal rectus was recessed, the left external rectus resected and the left inferior oblique myectomized

After operation the horizontal deviation was moderately overcorrected, with some weakness of the left internal rectus muscle In eyes directed down and to the left (the field of action of the right superior oblique) the vertical deviation was reduced by the operation on the superior oblique muscle from 30 to 0  $\Delta$  The prism measurements on the ninth postoperative day were

Eyes up and right	XT' 60— $\Delta$	RHT 5 $\Delta$
Eyes right	XT' 55 $\Delta$	HT' 0 $\Delta$
Eyes down and right	XT' 55 $\Delta$	LHT' 14 $\Delta$
Eyes straight	XT' 34 $\Delta$	LHT 0 $\Delta$
Eyes up and left	XT' 25 $\Delta$	LHT 16 $\Delta$
Eyes left	XT' 20 $\Delta$	LHT 5 $\Delta$
Eyes down and left	XT' 11 $\Delta$	HT 0 $\Delta$

The patient has not been seen since

*Comment*—The vertical deviation in eyes directed down and to the left (field of action of the right superior oblique) was reduced from 30 to 0  $\Delta$  by the tenotomy of the right superior oblique muscle This result was considered excellent The myectomy of the left inferior oblique reduced the left hypertropia for near, in eyes directed up and to the right, from left hypertropia of 30 to right hypertropia of 5  $\Delta$

#### GENERAL COMMENT

It is difficult to evaluate accurately the effect of any operation on the elevator muscles of the eye because the amount of vertical deviation present before and after operation varies with the position of the eyes

in adduction or abduction in the horizontal plane, as well as with the amount of elevation or depression of the eyes from this plane

Since the amount of deviation produced by overaction of the right superior oblique, for example, varies from a position of eyes directed to the left to a position of eyes directed down and to the left, being less in the former and greater in the latter, it was decided to tabulate the amount of deviation in these two positions before and after operation to determine just how much correction had actually been achieved by the operation. In all these cases it was noted that the greater amount of correction occurred in the field of greatest action of the superior oblique muscle. The patients were divided into three groups. Group 1 comprised 4 patients with simple tenotomy lateral to the superior rectus muscle, group 2 was made up of 6 patients with simple tenotomy on the nasal side of the superior rectus muscle, and group 3 was composed of 10 patients with tenectomy on the nasal side of the superior rectus muscle.

In group 1 there were 2 complete failures, 1 partial success and 1 good result. In the patient with a good result (case 4) a left hypertropia in eyes directed down and to the left was reduced from an estimated hypertropia of  $25\Delta$  to a hypertropia of about  $5\Delta$ . The poor showing in this group was attributed partly to timidity and lack of experience on the part of the surgeon, but mostly to the fact that one can never be entirely sure that all the fibers of the superior oblique muscle have been completely freed from the globe when the tenectomy is done lateral to the superior rectus muscle.

In group 2 there were 2 failures. The failures were attributed to cutting the sheath of the superior oblique muscle rather than its tendon. Once one has seen the pearly white, glistening tendon of the superior oblique muscle, one will never again confuse it with the sheath, which, by comparison, is white and semitendinous. Failure to cut the tendon will certainly produce no correction. Of the 4 remaining patients, each had from 13 to  $15\Delta$  of correction in the field of greatest action of the superior oblique muscle.

In group 3 there were 10 tenectomies of the superior oblique muscle with not a single failure. The amount of correction in the field of greatest deviation varied from 10 to  $30\Delta$  for a tenectomy of 5 to 7 mm, with an average correction of  $21\Delta$  for the group as a whole. Two patients (cases 9 and 13) obtained  $30\Delta$  of correction from a 5 mm tenectomy, while 1 patient (case 11) had  $10\Delta$  of correction with a 5 mm tenectomy on the right eye and  $15\Delta$  of correction from a 7 mm tenectomy on the other eye. In cases 9 and 13 there was a pronounced overaction of the superior oblique ( $30\Delta$ ) while the overaction in the other cases, in which the amount of correction was less, was also less pronounced. This may mean that a 5 mm tenectomy of the superior oblique, according to

the technic described here, will produce from 10 to 30  $\Delta$  of correction, depending on the amount of overaction of the muscle. This series of cases is entirely too small to justify a dogmatic statement about how much correction a 5 mm tenectomy will produce in a given case. Only time and more experience will give the correct answer.

It is interesting to note that more than one-half the cases reported here were associated with an exotropia, which increased in eyes directed down and decreased in eyes directed up. If esotropia was present, the esotropia decreased in eyes directed down. This behavior was attributed to the abducting power of the superior oblique muscles in the lower fields. It is interesting to recall that just the opposite occurs with bilateral overaction of the inferior oblique muscle, i.e., the esotropia becomes less in eyes directed upward and greater in eyes directed down. In 5 of this series of cases there was bilateral congenital overaction of the superior oblique muscle, in 3 cases the overaction was unilateral and congenital, in 2 cases it was secondary to injudicious surgical procedures on the direct antagonist (the unilateral inferior oblique), and in 2 cases the overaction was first discovered after previous operation on one or more of the extraocular muscles other than the inferior oblique.

#### SUMMARY

Overaction of the superior oblique muscle may be congenital or acquired in origin. As a cause of hypertropia, it is second in frequency only to overaction of the inferior oblique muscle. It may cause ocular discomfort, headaches, reading difficulties, vertical diplopia, head tilting and torsional difficulties. It is characterized by a vertical deviation which increases in adduction and in the lower temporal fields.

Overaction of the superior oblique muscle is best treated by tenotomy or tenectomy of the offending muscle. This operation is best done under Tenon's capsule on the nasal side of the superior rectus according to the technic already described. For adults local anesthesia is sufficient. For children a general anesthesia is necessary. Simple tenotomy will produce from 5 to 10  $\Delta$  of correction. A tenectomy will produce from 10 to 30  $\Delta$  of correction, depending on the amount of tendon removed and the amount of overaction present. This operation does not produce paralysis if the sheath is not severed along with the tendon.

In the past nine years, 20 tenotomies or tenectomies were done on 13 consecutive patients. In none of these patients was a discernible weakness of the superior oblique muscle produced. In 4 out of 10 tenotomies the tendons were presumably incompletely severed and the results were unsatisfactory. In all the tenectomies the result was good.

## CONCLUSIONS

1 Tenotomy or tenectomy of the superior oblique muscle is a simple, effective and reliable procedure for the treatment of hypertropia associated with overaction of this muscle

2 This procedure does not produce paralysis of the superior oblique muscle, nor does it produce any other complication

3 The amount of correction needed in each individual case can be graded by varying the amount of tendon removed

4 This operation is best done on the nasal side of the superior rectus muscle under Tenon's capsule according to the technic described

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# IONTOPHORESIS WITH CONTACT LENS TYPE AND EYECUP ELECTRODES

Some Points of the Theory and Technic of Ion Transfer

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**I**ONTOPHORESIS (ion transfer, ionization) has been employed in general medicine for over one hundred years. Although it has been used in the treatment of diseases of the eye for more than fifty years, it is still a comparatively unknown form of ocular therapy. From three to fifteen times greater concentrations of drugs can be obtained in the tissues of the conjunctiva, cornea and anterior segment of the eye by iontophoresis than by the topical application of the same drugs. For this reason mydriasis can usually be obtained by the iontophoretic introduction of atropine sulfate in the case of pupils that are refractory to the topical application or the subconjunctival injection of mydriatics. Anterior synechias may also be broken by this method when other methods fail. The theories and experimental and clinical data of iontophoresis as they apply to general medicine are thoroughly discussed by Abramowitsch and Neoussikine<sup>1</sup> in their book on "Treatment by Ion Transfer." In this paper only my apparatus, the theory of ion transfer, and some technical points applicable to ocular iontophoresis are discussed.

There are several reasons why iontophoresis has not been employed in ophthalmology as extensively as it should be. One of these reasons is that exaggerated claims have been made for the value of this form of therapy. Such claims naturally make the conservative ophthalmologist unwilling to try the method, particularly if it seems somewhat complicated to carry out. Another reason is that it is difficult to get a clear idea of the theories involved in iontophoresis from textbooks or from the contemporary literature (both domestic and foreign). The result of this is that the novice may apply the medicament to the wrong electrode and under these conditions does not succeed in introducing the proper fraction of the drug into the tissues. Now that the importance of obtaining high concentrations of the sulfonamides, penicillin and other antibiotic drugs in the tissue in the treatment of certain inflammations of the cornea and anterior segment of the globe is recognized,

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<sup>1</sup> Abramowitsch, D., and Neoussikine, B. Treatment By Ion Transfer (Iontophoresis), New York, Grune & Stratton, Inc., 1946



iontophoresis is likely to be more extensively employed. Another reason for the neglect of this form of therapy in ophthalmology is the difficulty of obtaining the proper equipment to carry out this procedure. The zinc and other metallic eye applicators frequently used, although covered with cotton or felt, may cause abrasions of the cornea, especially when treatment has to be carried out on several successive days.

With the aid of the House of Vision,<sup>2</sup> I have devised an apparatus and applicators that are simple to use and do not endanger the cornea. Many of the best features of the apparatus and of the electrodes have been a part of similar equipment used by different oculists for a long time. The combination of all these desirable features seems to make the apparatus particularly adaptable for use in ophthalmology. The apparatus is also equipped with an electrode for use in the electrolytic epilation (electrolysis) of misdirected cilia and the destruction of small papillomas, telangiectases and other small growths of the lids and of the conjunctiva by electrolysis.

The apparatus consists of a portable box measuring 11 inches (27.9 cm) in length,  $8\frac{1}{4}$  inches (20.9 cm) in width, and 7 inches (17.7 cm) in depth. It is powered by replaceable B batteries connected by a voltage regulator to a voltmeter, which registers from 0 to 50. With ordinary use the batteries should be good for over a year. An ohm resistor is connected through a rheostat to a milliammeter which registers from 0 to 5 milliamperes. In the upper left hand corner of the panel is an automatic pushbutton which turns the current on when the lid of the box is opened. The voltmeter is on the left hand side of the middle of the panel. Below it is a switch which turns to the right to increase the voltage from 6 to 12, 24 and 48. To the right of the voltmeter is a milliammeter controlled by a switch just below it. The switch is turned clockwise (to the right) to increase the amperage. In the lower left hand corner are two posts for plugging in the wire or wires for the negative pole (cathode), while the lower right hand corner has two red posts for plugging the wire or wires into the positive pole (anode). The connecting wires and active electrodes are in separate compartments at the back of the instrument. These compartments are covered by a felt pad. The indifferent aluminum hand electrode measures 9 inches (22.8 cm) in length and  $\frac{7}{8}$  inch (2.1 cm) in diameter. It fits into a groove on the inner surface of the cover of the box.

The hand electrode has the advantage over the usual flat leadfoil electrodes applied to the nape of the neck and other parts of the body in that there is no burning sensation at the place of contact with the skin. It avoids the electrical stimulation of the brain, sometimes evidenced by vertigo and headaches, which may follow iontophoresis when one

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<sup>2</sup> Distributors, The House of Vision, Chicago

electrode is applied to the eye and the other to the nape of the neck. For special purposes, such as animal experiments,  $5 \times 7$  inch ( $127 \times 177$  cm) flat electrodes may be substituted for the hand electrode. Only one insulated wire need be attached to it. The hand electrode, too, may be used with only one insulated wire plugged into one end of it. The contact, however, is much better when one wire is inserted at each end of the hand electrode, the other end of each wire being connected to the proper pole on the instrument panel. The double connection of the hand electrode and its greater length, permitting it to be grasped by both hands, make this electrode different from other hand electrodes hitherto employed.



Fig 1—Iontophoresis with contact lens electrode. Note eyecup electrode on instrument. The patient is holding the hand electrode.

The active electrodes are made of "lucite" (methyl methacrylate). One of them consists of a contact lens base with a narrow chimney extending from its center. Five millimeters above the corneal portion is a circular piece of platinum wire, partially embedded in the lower portion of the funnel. This is connected to an insulated flexible wire (Stoker<sup>3</sup> devised various glass electrodes that can be applied to the eye).

<sup>3</sup> Stoker, cited by Schnyder, W. F. Iontophorese in Ophthalmologie, Klin Monatsbl f Augenh. **63** 433, 1919.

These electrodes, as well as Birkhauser's<sup>4</sup> glass electrode, are not of the contact lens variety. Van Heuven<sup>5</sup> devised a contact lens electrode made of glass. From the center of the corneal contact lens base a narrow stem extends forward. This broadens into a wide ampulla which has two openings, a wide lateral one for the introduction of a spiral metal electrode and a narrow one at the apex of the ampulla through which the medicament is injected into the ampulla with a syringe. Von Sallmann<sup>6</sup> uses a Van Heuven electrode made of "lucite"). The other applicator consists of an eyecup, also made of plastic. At the bottom of the cup is a platinum wire connected to a thin insulated cord. Eye applicators made of glass have been described before. Plastic eyecup electrodes and hollow stem eyecup electrodes with removable base have not been described before, as far as I know. The stem of the eyecup is



Fig 2—Contact lens electrode. A circular platinum wire is on the inner surface, just above the junction of the wide scleral portion with the narrow chimney of the electrode (inner diameter of chimney 8 mm). The oval plastic plate on the left side of the chimney covers the area of junction of the flexible connecting wire (to pole of battery) with the platinum electrode.

hollow, the base fitting into the stem like a ground glass stopper into a bottle. This arrangement permits the use of this electrode like an ordi-

4 Birkhauser, R. Experimentelles und Klinisches zur iontophoretischen Behandlung von Hornhauttrübungen mit der Rohrenelektrode, *Klin Monatsbl f Augenh* **67** 536, 1921.

5 van Heuven, J. A. Ueber Glaukosan-Iontophorese, *Arch f Augenh* **106** 625, 1932.

6 von Sallmann, L. Penicillin and Sulfadiazine in the Treatment of Experimental Intraocular Infections with *Staphylococcus Aureus* and *Clostridium Welchii*, *Arch Ophth* **31** 58 (Jan) 1944, footnote 16.

may eyecup, that is, filled with the solution and then inverted over the eye, or placed on a table with the patient leaning over until the eye is immersed in the solution. In patients who have to lie on their back and on whom the contact lens electrode cannot be used the base of the cup is removed. The cup is placed over the eye and filled with solution through the hollow tubular stem of the cup. The iontophoresis then proceeds as explained in the section on the technic of iontophoresis.

The active electrode employed in electrolysis for the epilation of misdirected eyelashes and for the destruction of small growths of the lids or conjunctiva consists of a fine steel needle. There is a fine blunt



Fig 3—*A*, Plastic eyecup electrode ready for use as a conventional eyecup electrode. The white line at the base of the flaring portion of the eyecup indicates the partially embedded circular platinum electrode on the inner surface of the cup. *B*, the electrode with the base removed. The base fits into the hollow stem like a ground glass stopper into a bottle. The connection of the flexible connecting wire with the platinum wire electrode is protected by the oval plastic plate near the neck of the eyecup.

needle for removal of hairs and a slightly heavier pointed needle for the treatment of papillomas, etc.

#### SOME THEORETIC CONSIDERATIONS OF IONTOPHORESIS

Some of the molecules of salts, acids and bases when dissolved in water, undergo dissociation or ionization. The less concentrated the solution, the more molecules become dissociated into ions. These ions are

electrically charged. The electropositive ions are called cations because they are attracted to the negative pole or cathode during electrolysis. The electronegative ions or anions are attracted to the positive pole or anode. It is thus seen that the two kinds of ions are designated by the pole to which they are attracted rather than by the electric charge which they carry. In an aqueous solution of acids some molecules dissociate into positive hydrogen ions and negative acid radical ions. In a salt solution the dissociation is into positive metal ions and negative acid radical ions. In a solution of a base the dissociation is into positive ions of a metal and negative hydroxyl ions. When the electric current of a battery is turned on, one electrode receives a positive charge, the other receives a negative charge. The direction of the flow of the current is from the positive pole (anode) toward the negative pole (cathode). If the current passes through an electrolyte (that is, through aqueous solutions of substances that conduct electricity), the electropositive ions or cations travel toward the negative pole or cathode. The anions or electronegative ions are attracted toward the positive pole or anode.

In order to drive the proper ions into the tissues, one should know whether one wants to carry the ions with the positive or with the negative electric charge into the tissues. The electrodes are then arranged in such a way that the flow of the current is through the tissues of the eye toward the indifferent electrode held in the hands. This means that the eye electrode is at times connected to the positive pole of the instrument, at times to the negative pole, depending on the substance used for iontophoresis. Thus when atropine sulfate is used for iontophoresis, the purpose is to have the electropositive atropine ions go through the cornea toward the indifferent hand electrode. Since the flow of current is from the positive pole toward the negative pole, the wires of the hand electrode must be connected to the negative pole of the instrument and the active electrode (eye applicator) to the positive pole. In this way the positive charged atropine ions pass through the eye toward the negative pole, to which they are naturally attracted. If the electrodes were connected in an opposite manner, the sulfate ions would penetrate through the cornea while the atropine ions would be repelled. In the case of sodium sulfathiazole, the eye applicator filled with this solution is attached to the negative pole while the hand electrode is connected with the positive pole of the battery set. If the eye applicator were attached to the positive pole, the positively charged sodium ions would penetrate the cornea on their way toward the negatively charged hand electrode while the negatively charged sulfathiazole ions would be repelled from the cornea. In other words, in order to cause electropositive ions to enter the eye, the eye electrode must be connected with the positive pole. For electronegative ion transfer, the eye electrode is connected with the negative pole. This arrangement of the electrodes permits the proper ions to pass

through the eye toward the opposite (hand) electrode, to which they are attracted

A partial list follows of substances arranged in accordance with the proper connections of the eye electrode to the poles of the battery in order to cause penetration of the therapeutically effective ions into and through the cornea

*Eye Electrode Connected With Positive Pole (Anode)*

Atropine sulfate  
 Physostigmine salicylate  
 Pilocarpine nitrate  
 Acetylcholine chloride or bromide  
 Carbamoylcholine chloride  
 Acetyl beta methylcholine chloride  
 Streptomycin hydrochloride or sulfate  
 Quinine bisulfate, hydrochloride, and other salts of quinine  
 Epinephrine hydrochloride  
 Copper sulfate and other salts of copper  
 Zinc sulfate  
 Histamine  
 Calcium chloride and lactate

*Eye Electrode Connected With Negative Pole (Cathode)*

Penicillin sodium and penicillin calcium  
 Sodium sulfathiazole and other sodium salts of the sulfonamides  
 Potassium iodide and other salts of iodine  
 Sodium chloride  
 Sodium salicylate

CONCENTRATION OF SOME SOLUTIONS USED FOR IONTOPHORESIS

Since iontophoresis causes a concentration of ions in the tissues and also prolongs the action of drugs, only weak solutions should be used. The following concentrations of the drugs have been found effective by different authorities: penicillin, 1,000 Oxford units per cubic centimeter, sulfonamide drugs, 5 per cent, atropine, 0.25 per cent, pilocarpine, 0.1 per cent, acetylcholine, 1-400, quinine salts, 0.5 per cent, calcium salts, 0.5 per cent, epinephrine, 1-20,000, zinc sulfate, 0.25 per cent.

SOME POINTS ON TECHNICS OF IONTOPHORESIS

Ordinarily no topical anesthesia is necessary. In patients who have highly inflamed eyes and in those who are very apprehensive, as well as in children, the eye may be anesthetized by the instillation of a drop of tetracaine hydrochloride, 0.5 per cent solution, or some similar topical anesthetic. I have used the contact lens electrode on small children, the youngest a child of 18 months of age, after topical anesthesia with tetracaine hydrochloride. When the contact lens electrode is used, the patient should lie flat on his back. The hand electrode, into each end of which an insulated cord has been inserted (the other ends of the cords having

been plugged into the positive or negative poles of the instrument, as indicated by the medicine to be used—for details see the preceding paragraphs), is grasped firmly with both hands by the patient. The lids are separated and, with the patient keeping both eyes open and looking straight up at the ceiling, the applicator is inserted between the lids so that the broad base comes to lie on the sclera around the cornea. The lids are then released. The patient is instructed to keep both eyes open and to look straight up throughout the treatment. In this way the cornea will not be touched by the applicator. The insulated cord to which the eye applicator is attached was previously plugged into the proper pole of the battery. The medicament to be used is then poured into the chamber of the electrode with a medicine dropper. The platinum wire must be kept immersed in the solution. It is best to fill the chimney to the top, as some fluid might escape around the base of the electrode during the treatment. The electrode is steadied by the operator while the treatment is being given. If there is some escape of fluid, more medicine is added and slight downward pressure is made on the electrode to prevent further seepage around the base. The switch controlling the voltmeter is turned to number 24 on the panel and the switch controlling the milliammeter is turned slowly to the right, in the direction of the arrowhead, until  $1\frac{1}{2}$  or 2 milliamperes is registered on the dial. If not enough current is available, the milliammeter switch is turned back to the left as far as it will go and the voltmeter switch is advanced to 48 volts. The milliammeter switch is now again turned slowly until the desired milliamperage is obtained. One should not go beyond 2 milliamperes. If the battery should be low, the current can be stepped up by placing a piece of cotton, moistened in salt solution or in tap water (distilled water is a nonconductor), over the hand electrode. At the end of the treatment the voltmeter and milliammeter switches are slowly turned back to zero and the electrode is removed from the eye, the content of the eye applicator being mopped up with cotton.

The eyecup electrode is used when the contact lens electrode cannot be employed for some reason, such as excessive apprehension on the part of the patient, deformity of the globe, concomitant inflammations of the lids, etc. It is also useful in treating conjunctivitis and blepharitis through the closed lids. For treatment of the cornea or of the intraocular structures the lids should be kept open so that the cornea is immersed in the solution during the treatment. In ambulatory patients the cup is filled with the solution and placed over the eye in the manner of the ordinary eyecup, that is, the cup is placed on a table and the patient bends his head until the eyecup fits over the orbit, or he holds the eyecup in his hand and bends over until the eye is immersed and then pressing the cup to the orbit, tilts his head back. In patients who have to lie on their back and on whom the contact lens electrode cannot be used, the base

of the cup is removed, and the cup is placed over the eye and filled with solution through the hollow stem. The arrangement of the hand electrode and control of the current are the same as when the contact lens electrode is used. The period of treatment should not exceed two to five minutes. Treatments may be repeated daily or every second day for four or five treatments.

Occasionally a slight clouding of the cornea may develop after iontophoresis. This usually clears up within a few hours. No bandage or medication is necessary after treatment, unless indicated by the underlying pathologic process.

The "lucite" electrodes should be sterilized before and after being used. They should not be boiled as heat softens them. Alcoholic solutions cause them to become cloudy. They may be sterilized by immersion for twenty minutes in aqueous merthiolate, aqueous "metaphen" (nitro-mersol), or 1:1,000 "zephiran" (benzalkonium chloride).

#### ELECTROLYSIS FOR MISDIRECTED LASHES, DESTRUCTION OF SMALL GROWTHS ON THE LID AND CONJUNCTIVA

For misdirected lashes and small growths the active electrode, consisting of a fine steel or platinum needle, is connected, by a flexible, insulated cord, to the negative pole of the instrument. The indifferent hand electrode is connected to the positive pole by the two cords which are plugged into the ends of the electrode. The lid should be anesthetized by infiltration of procaine-epinephrine under the skin for electrolysis of eyelashes, and also along the adjacent fornix if the tarsus is to be treated. A binocular loupe should be worn by the operator, particularly when the follicles of eyelashes are being destroyed. The needle (the fine blunt needle is preferable) is introduced into the hair follicle along the shaft of the eyelash and the current is turned on by setting the switch of the voltmeter at 48. The milliammeter switch is then slowly turned until 2 to 4 milliamperes are registered. The needle is left in place for thirty to forty-five seconds or until hydrogen bubbles are seen around the mouth of the hair follicles. The current is then turned off, and the needle is removed. The hair should lift out with epilation forceps without any resistance. If resistance is met, the needle should be reintroduced into the hair follicle and the current turned on again.

Small growths are treated in the same manner. The sharp pointed needle is introduced in several areas, depending on the size of the growth, and each one coagulated as already described. It may take a week or two before the shrunken growth disappears completely. It is better to repeat the electrolysis several times than to destroy too much tissue.



## NEUROFIBROMATOSIS IRIDIS (RECKLINGHAUSEN'S DISEASE)

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WITH the present report of 2 cases is given a short survey of neurofibromatosis (Recklinghausen's disease) with signs referable to the iris

### REPORT OF CASES

CASE 1—I C, a youth aged 16, from Kefar Sabah, came to the clinic on May 5, 1945, complaining of an itching sensation in the eyes, like that of vernal conjunctivitis. Routine examination with the slit lamp revealed mixed gray and brown granules in the iris. The nodules varied in size, some were globular and others flat. Except for these formations in the iris, there were no pathologic changes in the eyes. Vision was 6/6 in each eye. On other portions of the body, e g, the neck, trunk and extremities, there were pigmented areas of various sizes, some of them being confluent brown spots. No changes were demonstrable in the bones or the skull.

CASE 2—S G, a youth aged 15, from Kefar Chassidim, was seen on May 24, 1946, with the complaint of poor sight in his right eye. The squareness of his skull struck the eye at once. The boy's appearance, like his voice, gave the impression that he was older than his age. His body was small, as though pressed together, and the bones were coarse. Examination of the eyes revealed a cicatricial trachoma without corneal complications. On the right side there were slight ptosis with enophthalmos and miosis (Horner). In the iris of each eye were many nodules, of various sizes and color, from café au lait to dark brown, with several telangiectases on the surface, some of the nodules were confluent. The pupil of the right eye reacted to light. The lens was almost entirely opaque.

Vision was limited to perception of hand movements at 0.5 meter. Light projection was prompt in all directions. The left eye presented no abnormalities except for the neurofibromatosis of the iris. Vision was 6/6. Tension in the right eye was somewhat reduced as compared with that in the left eye. The Wassermann and Mazzini reactions of the blood were negative. Many pigmented areas were noted on the neck, the body and the arms, varying from the size of freckles to that of the palm, especially in the left submammary region, where a large, fibroma-like swelling was present under the skin. In addition, the patient presented hirsutism, hypermastia and kyphoscoliosis. Roentgenographic studies showed no changes in the sella turcica, and bony thickenings were observed only at the cranial sutures. Medical and neurologic examinations revealed nothing significant. Intelligence was not reduced.

### COMMENT

Neurofibromatosis belongs to a group of diseases which result from systemic developmental abnormalities of the ectoderm and mesoderm (anomalies of bone). Included in this group are infantile progressive

hypertrophic neuritis, tuberous sclerosis (Bouineville), dystrophia pigmentosa (Leschke), and congenital obesity with polydactyly and retinitis pigmentosa, known also as the Laurence-Moon-Biedl syndrome. Neurofibromatosis may also be associated with osteodystrophia deformans (Paget).

The first comprehensive description of the disease was given by von Recklinghausen in 1882. The disease may occur in two forms: (1) peripheral neurofibromatosis, including tumors in the skin and in the nerve trunks up to their exit from the dura, and (2) central neurofibromatosis, in which the tumors are situated intradurally in the nerves themselves or in the central nervous system. The disease was described as neuroinomatosis by Verocay. It may be associated with diseases of bone and polyglandular disturbances of internal secretion.

The tumors may appear wherever there are nerves. In the skin, the changes appear as tumors or pigmentations, thickly spread over the trunk and the limbs. The tumors range from growths the size of the head of a pin to flabby, elephantiasis-like tumors. There are also pedunculated tumors, which disappear on pressure but fill again when pressure is released. The tumors are frequently covered with a bluish, telangiectatic skin, sometimes containing areas of hair or giant comedones. Similar tumors are sometimes observed on the mucosa. Pigmentary changes in the skin and the mucosa appear in the form of café au lait spots or as depigmented areas (leukoderma) and in the iris as brownish pigmented tumors. Neurofibromas are always related to the nerves, accordingly, they appear in a string of pearls form in the choroid and as a plexiform neuroma (so-called *Ranke-neurom*) in the region of the eyes, ears, forehead and neck. They occur in the course of the vagus, acoustic and trigeminal nerves and along the sympathetic trunk, with special predilection for the cauda equina, in the medulla of the adrenal glands and in the spinal ganglions, but seldom in the liver, the kidney or the brain and its covering. Malformations, such as uterus bicornis or a missing kidney, may occur as well.

*Pathologic Anatomy*—Macroscopically, neurofibromas are grayish red and of various sizes, and the nodular form may be rounded, spindle shaped, stalked or flabby. The tumor is related to a nerve, which may also penetrate the tumor. Microscopically, the growth consists of compact fibrous tissue with numerous oval or oblong nuclei and no sharp cell walls. The nuclei are arranged in palisade formation. In cross section the cells have an onion skin arrangement, the "peritubular" form, with an axis-cylinder in the center. The abundance of nuclei suggests sarcoma. Besides the cells, there is a reticulum-like tissue.

*Skin*—Normally there are two types of nerve endings. The neurilemma, or the so-called sheath of Schwann, is changed into a capsule (Meissner corpuscles) in the skin. 2. Nonmedullated fibers penetrate

the basal layer of the epithelium and ramify about two special cell types (*a*) the so-called Merkel-Ranvier corpuscles and (*b*) chromatophores. It has been proved that cutaneous nevi arise from neoplastic proliferation of these differentiated end organs, which have no longer any similarity to the structure of their original cells, but which are associated with medullated and nonmedullated cells. Dermal elements take part in some tumors, while in others there are epithelial elements or both. The nerve cell can become a chromatophore, thus forming the normal tissue chromatophore.

*The Eye*—Pigment formation normally occurs only in embryonic life, but with the malignant degeneration of the tumor the embryonic cell activity returns and the cells once more become dopa positive. Pigment formation is, therefore, only the expression of a changed metabolic activity. Malignant neural tumors (neurogenic sarcoma) and sarcomas resemble each other strongly. Both have a fibrillar structure and numerous spindle cells, but the neurogenic tumors have not only spindle-shaped forms but oval and other types. All neurofibromas, plexineuromas, ganglioneuromatous nevi, melanomas and certain sarcomas (as mentioned before) are of neurogenic origin. Their cells arise from Schwann cells. Neurofibroma rarely occurs in the conjunctiva or in the sclera.

The choroid receives many vasomotor and sensory nerves from the ciliary nerve. They form ganglions, malignant tumors are observed in the outer layers of the choroid. One may conclude, therefore, that there is a connection between the chromatophores of the uveal tract and the nerve fibers which control these cells. Neurogenic tumors of the uveal tract are like Recklinghausen's neurofibroma, benign nevi and malignant tumors (sarcoma) in that they are not of mesodermal, but are of neuroectodermal origin. Benign nevi may appear together with malignant nevi in the same eye and they may mingle with each other in the iris as well as in the choroid. Theobald established the connection between malignant melanoma and the ciliary nerves. The alveolar structure and polymorphous cells of some sarcomas of the uveal tract prove their ectodermal origin. Sensory corpuscles resembling ganglioneuromas also occur. Thus, there are two kinds of tumor cells: (1) spindle-shaped Schwann cells and (2) pigment cells, not at all resembling the former, but presenting a strange metamorphosis of neural elements. Plexiform neuroma of the choroid is rare and occurs with buphthalmos. The latter, however, may have been caused by defective development of the angle of the anterior chamber. The papilla is excavated, the choroid and ciliary body may both be replaced with fibrous tissue rich in nuclei and of exuberant growth (arising in Schwann's sheath). The iris is seldom affected by neurofibromatosis. As shown in the accompanying figures there occur areas of various sizes and small granules, part of

which are globular and part confluent. Some are mushroom-like, are attached to the iris and have a superficial capillary network. Their color varies from café au lait to coffee-brown. The nodules project from the surface, or remain on the level, of the iris. Except for the margin of the pupil, nearly all parts of the surface of the iris are invaded. The fibroid swellings have a strong tendency to sarcomatous degeneration.

The differential diagnosis is important when the fibromas occur singly, as in the case of warts (which do not have a smooth surface), lesions of cysticercosis (the consistency of which is hard), lipoma (which has no pigmentation) and the cutaneous metastases of carcinoma. The diagnosis of central neurofibroma is suggested in cases in which fibromas and pigmentations of the skin occur in the presence of symptoms of a brain tumor. Especially important is the differential diagnosis of

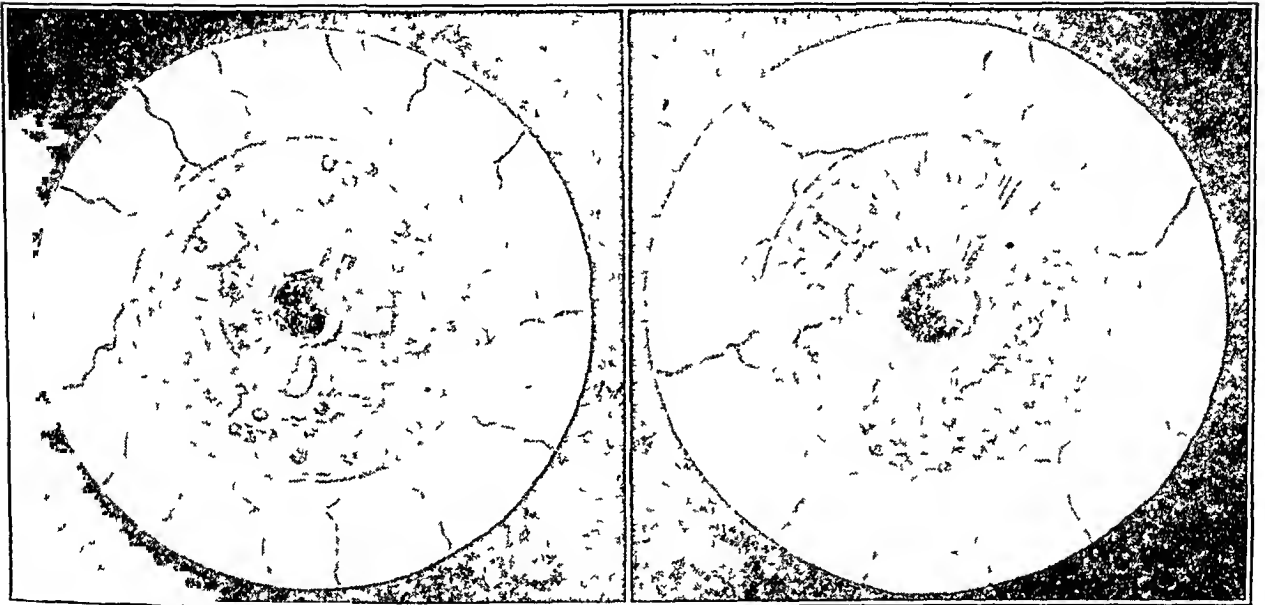


Fig 1—Irides in case 1

cerebellopontile tumors (acoustic neurofibroma). As for general neurofibromatosis, therapeutic measures are without avail. In the case of a single lesion operation is indicated.

*Course of Neurofibromatosis*—Neurofibromatosis may be congenital or it may develop after birth. The tumors may grow quickly, slowly or interruptedly (pregnancy). During pregnancy, puberty and the menopause, and in connection with infectious disease and trauma tumors and pigmentations may occur and regress spontaneously. Central fibromatosis is dangerous, as the tumors tend to become malignant (Verocay).

*Pathogenesis*—The origin of the tumor is an imperfectly developed group of cells which have migrated from the medullary tube and form Schwann's sheath, and the tumor is therefore called a neurinoma. The course of the process resembles that of tuberous sclerosis (Bourneville) in that there occasionally occurs a combination of abnormalities

(phakoma) or undeveloped embryonic tissue with formation of a tumor (blastoma). The neurofibromas at the papilla in cases of tuberous sclerosis, as in those of neurofibromatosis, seem to be due to sudden disturbance in the equilibrium of embryonic growth, perhaps with endocrine factors.

In the neuroectodermal tumor there appears mesodermal tissue, so that it is difficult to differentiate the primary and the secondary part of the tumor. Unlike tuberous sclerosis, neurofibromatosis is hereditary, as is the tendency to malignant degeneration. Women are attacked as well as men. The symptoms increase with successive generations.

Associated signs of the disease are kyphoscoliosis, osteomalacia and acromegaly, the last is not caused by a neurofibroma, or by the pressure

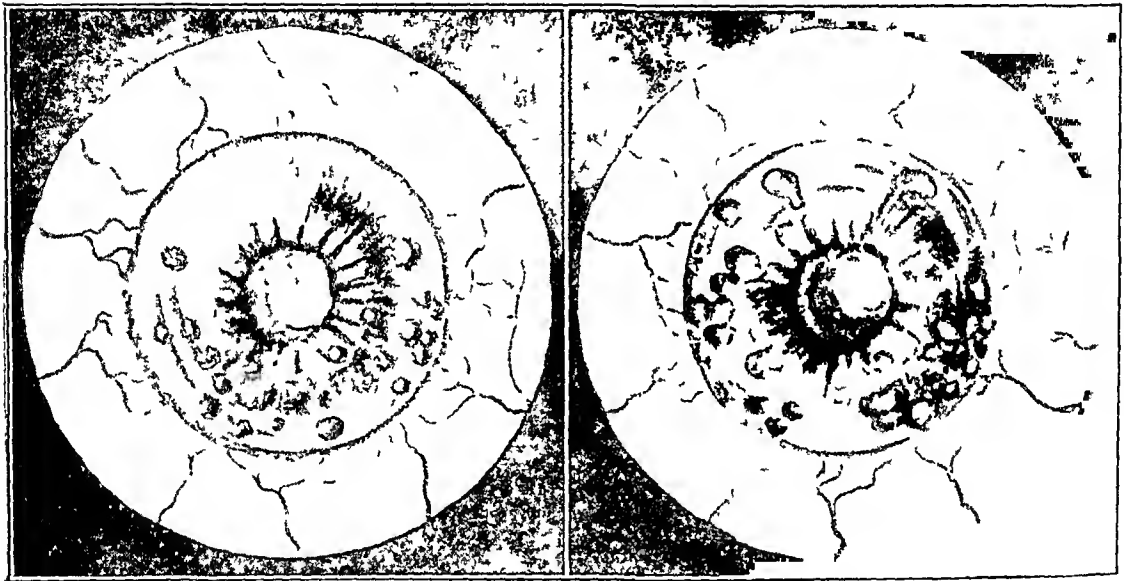


Fig 2—Iris in case 2

of a neurofibroma, in the area of the hypophysis but is a part of the disease. Associated symptoms of the disease are dystrophia adiposogenitalis, diabetes insipidus, myxedema (polyglandular insufficiency), scanty menstruation, retardation of growth, hyperfunction of the glands of internal secretion and hypermastia. There also occur psychopathic changes, such as reduction of intelligence, morbid shyness, or an inclination to violence, prostitution or epilepsy. Congenital anomalies, such as epispadias and exostoses, may be present.

#### SUMMARY

Two cases of neurofibromatosis (Recklinghausen's disease) involving the iris are described. In both cases the location in the iris was discovered in routine examination, and a general examination disclosed

the typical syndrome of the disease in other parts of the body, as well as involvement of the bones and the glands of internal secretion (cataract, hypermastia), signs which are usually associated with the disease. Location of the neurofibromatosis in the iris may not be as rare as is supposed if the possibility of the occurrence is kept in mind during examination with the slit lamp

## USE OF AIR INJECTIONS INTO TENON'S CAPSULE FOR LOCALIZATION OF ORBITAL FOREIGN BODIES

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THE EXACT localization of a single foreign body in relation to the globe is often extremely difficult, the presence of multiple foreign bodies complicates the problem proportionately. The military oculist is likely to encounter literally dozens of metallic or other fragments embedded in the tissues of the face, lids, globe, orbit, forehead, temple or nose. Most of these bodies may be ruled out as extraocular because of their remote position, but there often remain several which lie within the orbit, and possibly within the eye. To attempt to localize these fragments with the usual two plane exposures would require several tedious plottings. A still greater difficulty would be the virtual impossibility of distinguishing in the lateral projection between fragments which are intraocular and fragments which lie in the adjacent tissues or in the opposite orbit, temple, lids or side of the nose. Aside from these considerations, the x-ray equipment requisite for precise localization is frequently not available when needed.

The injection of air into Tenon's capsule<sup>1</sup> may be of considerable diagnostic value. The air outlines the contour of the globe, and this delineation provides a basis for judging the relative position of the suspected foreign body. If the foreign body is extraocular, it will be separated from the globe by the intervening air pocket. I have used this method in more than 20 cases and have found it exceedingly helpful.

A 10 cc syringe armed with a straight 26 gage hypodermic needle is the most satisfactory means of injecting the air. A curved cannula must, of necessity, be of wider bore, and the heavier needle is much more difficult to insert into Tenon's space without inflicting undue trauma to the tissues and provoking hemorrhage into the conjunctiva. The upper outer quadrant is perhaps the most accessible locus for retrobulbar injection, but the penetration may be easily effected in any one of the four quadrants.

If the position of the foreign body or bodies is known roughly, the injection may be made in that area. In cases in which the presence of adhesions about the globe is suspected, it may be advantageous to inject air into two quadrants.

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<sup>1</sup> Spackman, E W. *Am J Ophth* **18** 204-232, 1937. Staunig, K, and Herrenschwared, F. *Fortschr a. d Geb d Rontgenstrahlen* **36** 372-374, 1927. Gasteiger, H, and Grauer, S. *ibid* **40** 272-278, 1929. Hughes, W L, and Cole J G. Technical Uses of Air in Ophthalmology, *Arch Ophth* **35** 525-540 (May) 1946.

The injections should be made with proper regard for asepsis. The eyeball is rotated in such a direction as to expose most adequately the intended site. The conjunctiva and Tenon's capsule are grasped with a toothed forceps, and Tenon's space is entered, with the needle following the curve of the globe. The point of the needle is pushed to a position near the posterior pole. There is no danger of perforating the eye if the bevel of the needle faces the globe. The plunger of the syringe should be retracted slightly to permit warning against accidental entrance into a vein. The air is injected slowly. Ultimate leakage into the conjunctival interstices is inevitable, but this does not interfere with the desired results. However, if the conjunctiva balloons immediately, the needle is not in Tenon's space. In this event, the needle must be shifted to a deeper and more posterior position. The amount of air required is determined by the degree of exophthalmos induced, the resistance to the plunger and the extent of the conjunctival emphysema. Usually 6 to 10 cc of air is adequate. The eyeball will be seen to proptose slowly during the injection. A good injection should cause a proptosis of 2 to 3 mm, and an increase in intraocular pressure of 8 to 10 mg of mercury. The greater the volume of air, the more conspicuous will be the periocular shadow and the greater will be the displacement of any paraocular foreign body. The air is absorbed in five to seven days. There is little discomfort to the patient, and no untoward sequelae have been encountered in my experience. A patch should be worn over the eye for one or two days after the patient leaves the x-ray room.

The best roentgenograms are obtained when the patient is in the following position. The forehead, nose and malar bone rest on the cassette. The horizontal plane of the skull is perpendicular to the table, and the sagittal plane makes an angle of 52 degrees with the table. The tube is tilted toward the feet until the central ray makes an angle of 20 degrees with the horizontal plane of the skull. The beam is centered over the orbit nearest the film. Stereoscopic plates are made.

The cassettes must be scrupulously clean, if not, they will yield artefacts which may be indistinguishable from shadows of the true foreign bodies. If flawless cassettes are not at hand, cardboard film covers may be employed but one loses thereby the advantage of the intensifying screen which is built into the cassette. Higher roentgen energy is required without the intensifying screen, the amount approximates the epilating dose, and one must be careful not to overexpose the patient.

Bone-free exposures of the anterior ocular segment may be made at this time on dental film. The exophthalmic state of the eye will give opportunity for roentgenologic examination of more of the anterior segment than is usually projected in ordinary circumstances. It might be justifiable to inject air into Tenon's space for the sole purpose of bringing the cornea forward when bone-free films are required.

The clinical findings must always be correlated with the roentgenographic findings in interpretation of the plates. If the shadow of the foreign body falls external to the outlines of the globe, the foreign body must be outside the eye, such negative findings are always conclusive. Positive findings are less conclusive. The shadow of the foreign body may be superimposed on the shadow of the globe, yet the foreign body itself may lie outside the eye. The foreign body must lie outside the nearest tangential rays in order to register external to the outline of





Fig 1 (case 1)—Intraocular hemorrhage, traumatic chorioretinitis. Plam roentgenogram disclosed several foreign bodies in the region of the globe, more exact localization was not obtainable. Stereoscopic views taken after injection of air revealed four foreign bodies in the orbit, all outside the outline of the globe. In this figure, and in the accompanying figures, arrows indicate the outline of the globe.



Fig 2 (case 2)—Hemorrhage in the vitreous, traumatic chorioretinitis. After injection of air, eight foreign bodies were visualized within the orbital limits. Only two of them were within the outline of the globe, stereoscopic views revealed that one of these was outside the globe. The other was noted to be inside the eye, actually, it corresponded to a foreign body embedded deep in the cornea.

the globe. It may theoretically be necessary to make exposures from many angles in order to prove definitely that the foreign body is inside the eye, actually, however, this may be avoided by the use of stereoscopic films. In most instances the depth of the foreign body may be gaged with fair accuracy with the stereoscope. The films should be

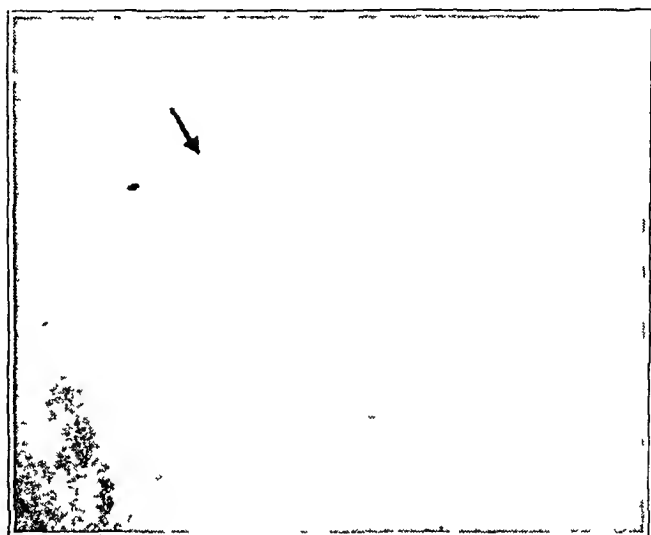


Fig 3 (case 3)—Small patch of chorioretinitis in an eye exposed to an explosion. There was no evidence of perforation, but plain roentgenograms disclosed a small fragment in the orbit. The presence of a foreign body within the eye was suspected. Roentgenograms taken after injection of air revealed the foreign body to be well outside the air pocket. In this case there had been double perforation, the anterior perforation having become invisible after healing.

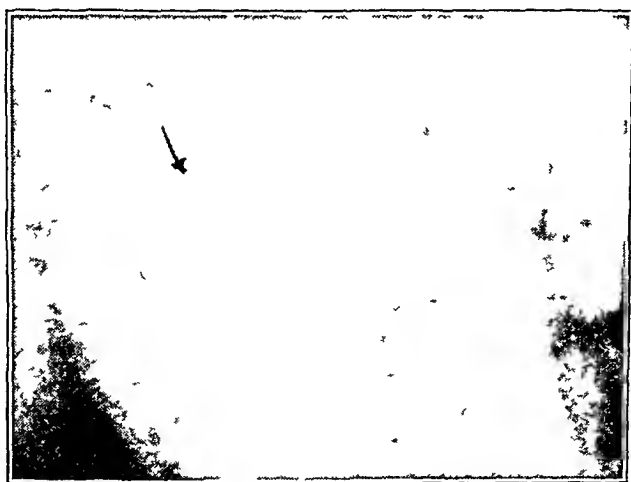


Fig 4 (case 4)—Perforating injury by a fragment from a grenade. Roentgenograms taken at another station with a localizing contact glass revealed a foreign body definitely outside the eye. Double perforation was suspected. Stereoscopic views taken after the injection of air localized the foreign body within the globe, the diagnosis being verified by examination of the globe after enucleation.

drawn close to the observer's eyes in order to obtain the optimum size of the images. Routine stereoscopic roentgenograms have been found expedient and practical.

Injection of air is contraindicated in the presence of a large, recent perforation or in cases in which immediate operation is contemplated. In such cases there is danger of extrusion of some of the ocular contents because of the increased external pressure. Scheie and Hodes<sup>2</sup> recommended the use of oxygen instead of air and found that most of the gas was absorbed within eight hours.

The 4 cases illustrated by the roentgenograms are representative of the clinical conditions under which the use of injection of air and stereoscopic roentgenograms may be expected to be of assistance. The illustrations are positive prints, and the foreign bodies have been retouched for accentuation in reproduction. Arrows indicate the outline of the globe.

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2 Scheie, H., and Hodes, P. J. Injection of Oxygen into Tenon's Capsule,  
*Arch Ophth* **35** 13-14 (Jan) 1946

# USE OF ABSORBABLE CORNEOSCLERAL SUTURES IN CATARACT SURGERY

Report of Seventy-Six Cases

L J ALGER, M D

GRAND FORKS, N D

**R**EMOVAL of sutures after cataract extraction has always presented a difficult problem. In removing the sutures, not only does one subject the eye to the hazard of rupturing the wound, one subjects the patient to an ordeal which he seems to dread almost as much as the original operation.

Anyone who uses corneoscleral sutures has been fortunate indeed if while removing these sutures he has never had the experience of rupturing the wound sufficiently to produce a hemorrhage into the anterior chamber. A number of good ophthalmic surgeons condemn altogether the use of corneoscleral sutures because of the hazards which they present on removal.

It is not surprising that recently several physicians have made an attempt to solve this problem by the use of absorbable sutures. Davis<sup>1</sup> reported the use of absorbable corneoscleral sutures in 70 cases of cataract extraction. Hughes, Guy and Romaine<sup>2</sup> reported a series of experiments on the relative merits of various absorbable sutures in a series of rabbit eyes. Because of the encouraging results reported by these authors, I have, during the past two and a half years, used absorbable sutures in 76 cases. Since no further report of the use of such sutures has recently appeared, I feel that the report of these cases may be of interest.

Like the authors cited, I did not find any noticeable difference in the amount of tissue reaction to these sutures and to ordinary silk sutures.

In addition to the recognized advantage that the removal of sutures is eliminated, three other advantages appeared.

1 The patient does not complain of the feeling of a foreign body in the eye. With the use of silk sutures, this sensation of a foreign body in the eye grows constantly worse as long as the sutures are in place. If the patient is uncooperative and sensitive to any manipulation, it may be necessary to allow the silk sutures to remain as long as two weeks before they can be removed without danger of injury to the eye. It is

1 Davis, F A. Catgut sutures in Operation for Cataracts, *Arch Ophth* **31** 321-323 (April) 1944.

2 Hughes, W L, Guy, L P, and Romaine, H H. Absorbable Sutures in Cataract Surgery, *Arch Ophth* **32** 362-367 (Nov) 1944.

most unpleasant to listen to patients constantly complain of the presence of a foreign body during the entire time that the stitches remain, and it is even more unpleasant and disturbing to watch them blink and squeeze the eyes in an attempt to rid themselves of the foreign body

2 The only postoperative hemorrhage in the present series was one into the anterior chamber, no postoperative prolapse occurred after the first twenty-four hours. The series is too small to permit conclusions, but I believe that the lessened feeling of a foreign body and the resulting lessened squeezing and blinking of the eye are responsible for these improved results

3 For the first three days, the discharge from these eyes is as great as, if not greater than, the discharge from eyes in which silk sutures were used. After the third day, however, the discharge rapidly disappears. When silk sutures are used, the discharge continues, and, in fact, grows worse as long as the sutures are allowed to remain

The operation used in this series is an adaptation of the techniques of several other surgeons. The Liegard suture (more commonly, but perhaps improperly, called "Stallard suture") is used with a Van Lint flap. This procedure is a variation of Gifford's method as illustrated by Bellows.<sup>3</sup> Unlike Gifford's regular suture, the ends of my suture are carried through the conjunctival flap before tying, so that the knot lies on the conjunctiva instead of directly on the corneal incision beneath the conjunctiva. This variation, too, is an adaptation of Gifford's method for the side extraction of a cataract, also illustrated by Bellows.<sup>4</sup> A round pupil is employed with a marginal iridectomy at 11 and 1 o'clock. Physostigmine is used when the operation is finished. No mydriatic is used prior to operation.

A point of interest is the color of the suture. It appears white, and as it absorbs one has the impression that the white suture remnant is an early infection of the corneal margin. If one does not recognize this, one will suffer unnecessary anxiety when looking at the eye on the second or third day.

Hughes and associates<sup>2</sup> used a variety of sutures, both chromic and plain. In the present series plain 0000 atraumatic surgical gut U S P was used exclusively. From my limited experience, I am inclined to disagree with Davis and others who advocate 00000 or 000000 surgical sutures. I feel that a 0000 surgical gut suture is none too large, and it does not absorb as rapidly as the smaller sutures. Davis used silk for his conjunctival sutures. I used 0000 surgical gut for these sutures as well. They hold firmly and do not release the conjunctival flap before the fifth day.

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3 Bellows J G. *Cataract and Anomalies of the Lens*, St. Louis, C V Mosby Company, 1944, p 549

4 Bellows,<sup>3</sup> p 556, fig 206, *Am J Ophth* 26 468, 1943

“I disagree with the statement made by Ellett <sup>5</sup> “Those who advocate catgut cannot realize the greater ease with which silk is handled, and the absorbability of the catgut is offset by its size” Instead of surgical gut being hard to handle, I find that it knots up less than silk Unlike silk, it slips readily through the conjunctival flap and does not wrap itself into the conjunctival tissue, catching when one tries to pull it through, as silk often does The thread will not split, as silk does When dipped in water, it is perfectly pliable Its larger size surely is not a condemnation, for it is more easily grasped with tissue forceps

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<sup>5</sup> Ellett, E C Use of the Suture in Extraction of Cataract, Arch Ophth  
**17** 523-529 (March) 1937

## SOLUTIONS USED WITH CONTACT LENSES

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A RESEARCH program was conducted throughout the year 1945 to obtain more information concerning the causes and prevention of clouding of the corneal epithelium by solutions used with contact lenses

To eliminate varying personal equations, I used my own eyes exclusively and employed the same pair of contact lenses in all experiments

### PRESENT INVESTIGATION

*Problem 1 Effect of Carbon Dioxide in Contact Solutions Used in Lenses*—It has been suggested that the carbon dioxide which passes through the cornea from the anterior chamber outward at the

TABLE 1—*Effect of Carbon Dioxide in Solutions Used with Contact Lenses*

Solution	pu	Osmotic Pressure	Time of Corneal Clouding
Sodium chloride, 14%	68	14	1 hr 45 min
Sodium chloride + carbon dioxide	46	14	1 hr 45 min
Borate buffer solution	88	14 (NaCl)	2 hr
Buffer solution + carbon dioxide	66	14 (NaCl)	2 hr
Sodium bicarbonate	84	144 (NaCl)	1 hr 50 min
Sodium bicarbonate + carbon dioxide	72	144 (NaCl)	1 hr 50 min

recorded rate of 0.05 cc per hour accumulates in the solution used with the contact lens and is responsible for, or is a contributing factor in, the clouding of the corneal epithelium

In order to evaluate the truth of this contention, a series of solutions ordinarily used with contact lenses were saturated with carbon dioxide before they were placed on the eye. Each solution was prepared in a glass seltzer water bottle of the type sold for home preparation of carbonated water. A tank of pure carbon dioxide with controlling valves and gages was used to supersaturate each solution under a pressure of 35 pounds (15.9 Kg) with vigorous agitation. The solutions were kept under pressure for twelve hours or more before use and were then ejected into a 50 cc beaker just before they were to be worn. Each solution was allowed to stand long enough for any free carbon dioxide to escape from the solution, in order to prevent bubbles of carbon dioxide from forming under the contact lens after it had been placed on

the eye. The  $p_H$  of each solution was taken before and after the saturation with carbon dioxide.

A 1.4 per cent solution of sodium chloride was first used. This had an initial  $p_H$  of 6.8 and a  $p_H$  of 4.6 after saturation with carbon dioxide. When placed on the eye, the saturated solution was extremely painful for about seven minutes, and considerable conjunctival injection took place. After the stinging subsided, the lenses were wearable but not so comfortable as with pure 1.4 per cent sodium chloride. Clouding of the corneal epithelium took place in one hour and forty-five minutes. This is the exact time that I can wear a 1.4 per cent solution of sodium chloride without added carbon dioxide. The severe initial stinging could be due to the acidity of the solution or to free carbon dioxide.

The second solution used was a sodium borate-boric acid buffer, with an initial  $p_H$  of 8.8 and an osmotic pressure of 1.4 (sodium chloride). After saturation with carbon dioxide, the solution had a  $p_H$  of 6.5. As with the solution of sodium chloride, there was an almost unbearable stinging for about ten minutes, with immediate injection of the conjunctiva. The injection subsided in about twenty-five minutes. Clouding of the epithelium took place in about two hours, which is the exact time the same solution without the carbon dioxide can be worn.

The third solution used was a 2 per cent solution of sodium bicarbonate ( $\text{NaHCO}_3$ ), with an initial  $p_H$  of 8.4 and an osmotic pressure of 1.44 (sodium chloride). After saturation with carbon dioxide, the  $p_H$  was measured as 7.2. As with the two previous solutions, there were an almost unbearably severe stinging and a conjunctival injection as soon as the lens was put on. In fact, the stinging was so bad that only the left lens was used in each of these experiments. Beads of perspiration were formed on the forehead, and I paced the floor. The stinging subsided in about six minutes and the injection in about twenty minutes. The lenses were worn for about one hour and fifty minutes before corneal clouding took place. This is the time that I can wear a 2 per cent solution of sodium bicarbonate without the added carbon dioxide.

With this last solution the  $p_H$  is on the alkaline side, which would indicate that the severe stinging is due entirely to the free carbon dioxide.

From these experiments, one can conclude that a solution saturated with carbon dioxide can be worn as long as the same solution without the carbon dioxide before corneal clouding takes place. Therefore, the presence of carbon dioxide in the solution does not hasten the clouding of the corneal epithelium. Considering that the addition of other substances, such as gelatin, to solutions for use with contact lenses will cause clouding in three to five minutes, it is not probable that carbon dioxide in solutions for use with contact lenses is the cause of clouding.



of the corneal epithelium. It is possible that the accumulation of carbon dioxide and lactic acid in the corneal tissues contributes to the clouding.

As the results of this experiment were unexpected, and contrary to the accepted theory concerning edema, further substantiation of the foregoing conclusions will be the objective of further experimentation.

*Problem 2 Effect of Added Oxygen to Solutions for Use with Contact Lenses*—It has been suggested that the isolation of the cornea from atmospheric oxygen is at least a contributing factor in clouding of the corneal epithelium when contact lenses are worn.

In order to obtain an idea of the part oxygen plays in this reaction, a series of solutions used with contact lenses were saturated with oxygen before use. The process of oxygenation was identical with that used to produce saturation with carbon dioxide except that oxygen was used instead. In this series, the  $p_H$  was not altered by the addition of oxygen.

A 1.4 per cent solution of sodium chloride was first used. When saturated with oxygen, it produced an immediate soothing and com-

TABLE 2—*Effect of Added Oxygen to Solutions Used with Contact Lenses*

Solution	$p_H$	Osmotic Pressure	Time of Corneal Clouding
Sodium chloride, 1.4%	6.8	1.4	1 hr 15 min
Sodium chloride + oxygen	6.8	1.4	2 hr
Sodium bicarbonate, 2%	8.4	1.44 (NaCl)	1 hr 50 min
Sodium bicarbonate + oxygen	8.4	1.44 (NaCl)	2 hr 10 min
Amino acid buffer	8.4	1.4 (NaCl)	2 hr 25 min
Buffer + oxygen	8.4	1.4 (NaCl)	2 hr 35 min

fortable sensation when in contact with the eye. The comfort lasted beyond the time clouding took place, two hours later. The wearing time before clouding was extended only fifteen minutes.

Next, a 2 per cent solution of sodium bicarbonate was used, with exactly the same reaction. The lenses were worn twenty minutes longer than without the added oxygen.

The third solution used was an amino acid-sodium borate buffer with an osmotic pressure of 1.4 per cent sodium chloride. The reaction of comfort was exactly the same in this instance and the wearing time ten minutes longer before clouding occurred.

If my eyes alone were considered, I should have to conclude that, while the presence of dissolved oxygen in contact lenses is soothing, it does not appreciably lengthen the time before clouding of the epithelium takes place. However, these oxygen-saturated solutions were used also with about 50 patients, who always reported greater comfort, with a reduction of the smarting and redness otherwise present and an added wearing time before clouding of up to an hour and a half. Added clearness of vision was also reported, due probably to reduction in formation of mucus with the reduced irritation.

It can be concluded, therefore, that solutions for use with contact lenses saturated with oxygen are comfortable to wear and in some cases lengthen the wearing time before corneal clouding takes place (table 2).

*Problem 3 Effect of Osmotic Pressure on Corneal Clouding*—It has been stated that an osmotic flow between the corneal cell contents and the liquid used with contact lenses is the principal cause of clouding of the corneal epithelium. On the contrary, it has also been said that variation of osmotic pressure has little value in controlling this phenomenon. In order to evaluate the role osmotic pressure plays in the formation and prevention of clouding of the corneal epithelium, several experimental procedures were carried out.

I have contended that the osmotic pressure of the tears as they are excreted from the glands is not the same as the osmotic pressure of

TABLE 3—Results of Using Solutions of Sodium Bicarbonate of Successively Higher Osmotic Pressures with Contact Lenses

Solution, %	Osmotic Pressure, (NaCl)	Time Solution Was Placed on Eye	Time Removed from Eye	N <sup>d</sup>	Comments
2.0	1.44	10 20 a m	10 55 a m	1 3348	Comfortable, no clouding
2.3	1.61	10 55 a m	11 30 a m	1 335	Comfortable, no clouding
2.5	1.75	11 30 a m	12 15 p m	1 3352	Comfortable, no clouding
2.7	1.89	12 15 p m	1 00 p m	1 3354	Comfortable, no clouding
2.8	1.96	1 00 p m	1 30 p m	1 3357	Comfortable, no clouding
3.0	2.1	1 30 p m	2 10 p m	1 336	Slight sting on insertion, no clouding
3.3	2.31	2 10 p m	3 40 p m	1 3363	Comfortable, no clouding
3.6	2.52	3 40 p m	4 20 p m	1 3368	Sting 10 min, no clouding
3.8	2.66	4 20 p m	5 05 p m	1 337	Slight sting 5 min, slight clouding on removal
4.0	2.8	5 05 p m	5 45 p m	1 3374	Severe sting 10 min, clouding gone in 3 min, no clouding on removal

the tears covering the cornea, it is contended, rather, that the lacrimal fluids of two general osmotic pressures exist. First, the tears covering the lids and the unexposed bulbar conjunctiva are substantially the same as when excreted. The osmotic pressure of this fluid has repeatedly been reported as equal to 1.4 per cent sodium chloride. However, the tears over the cornea and, to a less extent, over the exposed conjunctiva are, of course, subject to rapid evaporation of their water content. The film of tears is thin and the area affected relatively large. It is reasonable to expect the osmotic pressure of the tears over the exposed cornea to be above 1.4 per cent sodium chloride. There are no data published concerning the osmotic pressure of the tears over the cornea or of the contents of the corneal epithelium. I knew from experience that if a solution with an osmotic pressure of 2 per cent sodium chloride was used with a contact lens the conjunctival irritation was severe enough to cause considerable conjunctival injection and smarting, even though the cornea did not seem to be affected.

The first experiment in this series was to determine how high an osmotic pressure the eye would tolerate if an attempt was made to produce tolerance, using solutions of successively higher osmotic pressures over a continuous period throughout the day. The amazing results are shown in table 3.

When the lenses were removed at 5:45 p.m., the eyes were comfortable and there was no injection. However, once the lenses were removed, a slight clouding with rainbows about exposed lights was immediately observable and lasted about thirty minutes.

After it had been proved that the eyes could tolerate an osmotic pressure of twice the accepted limit, it was then thought desirable to determine the minimum number of changes necessary for a given period and the greatest successive variation possible. One of these experiments, using sodium bicarbonate, illustrates the results obtained (table 4).

These periods of five successive hours of wearing time were obtained, using only three solutions, with osmotic pressures of 1.4, 1.96 and 2.66,

TABLE 4—*Minimal Number of Changes During Continuous Wear of Solutions of Sodium Bicarbonate of Three Successively Higher Osmotic Pressures*

Osmotic Pressure	Time Worn Before Clouding	Comment
1.4	2 hr 30 min	Comfortable throughout wearing period
1.75	Changed at once	Comfortable
1.96	1 hr 10 min	Slightest sting on insertion, clouding cleared in 5 min
2.31	Changed at once	Comfortable
2.66	1 hr 50 min	Slight sting for 5 min, clouding cleared in 5 min

respectively. It is to be noted that the clouding from the preceding wearing period was cleared in five minutes after each change of fluid to one with higher osmotic pressure.

As improved solutions were devised, as described later in this paper, my continuous wearing time for contact lenses was lengthened to seven or eight hours, with only two changes after the initial insertion, three solutions of successively higher osmotic pressures, 1.4, 2.03 and 2.6, being used. The slight clouding which occurred before each change cleared in three minutes.

The next logical experiment was determination of the possibility of using solutions of an osmotic pressure higher than had previously been thought possible without the progressive changes described in the preceding paragraph. Numerous experiments with solutions for use with contact lenses heretofore reported in the literature indicated that use of such solutions was impossible because the stinging, injection and discomfort experienced when solutions of this type were used with an osmotic pressure slightly above 1.4 per cent sodium chloride precluded their use by the average patient. My own eyes would not tolerate them.

Fortunately, during the latter part of 1945, experimental work was done with more complex solutions containing amino acids, potassium carbonate and methyl cellulose, which proved wearable when made in concentrations with osmotic pressures up to 2 375 per cent sodium chloride. Once slight clouding had taken place, the lenses could be refilled with fresh solution of the same kind and worn for an additional two to three hour period of cloud-free vision. It is interesting to note in table 5 that the initial wearing period lengthened as the osmotic pressure increased.

It may be concluded from the foregoing experiments that the eye will tolerate the solution used with contact lenses with an osmotic pressure as high as 2 8 per cent sodium chloride if the eye is conditioned in the proper manner. Further, the useful wearing time of contact lenses can be lengthened by the use of three successively stronger solutions of the more usual type. Finally, solutions using certain organic materials have increased efficiency with an osmotic pressure of about 2 per cent sodium chloride. Certainly, one can state positively that

TABLE 5—*Wearing Times of Solutions of Amino Acids ("Parenamine"), Methyl Cellulose and Potassium Carbonate*

Osmotic Pressure	pH	N <sup>d</sup>	Wearing Time Before Clouding	Second Wearing Time Before Clouding *
1 4	8 5	1 3391	3 hr 40 min	2 hr
1 74	8 0	1 3418	3 hr 45 min	2 hr
2 037	8 6	1 342	4 hr 50 min	2 hr 30 min
2 375	8 0	1 3448	5 hr	3 hr

\* Clouding cleared in 5 minutes after second insertion of lenses

osmotic pressure is an important factor in a solution for use with contact lenses.

*Problem 4 Value of Amino Acids in Solutions for Use with Contact Lenses*—Most of the solutions used with contact lenses have been composed of simple inorganic salts, mixtures of such salts or inorganic buffer solutions. It seemed likely to me that the absence of large, complex organic molecules, such as are present in the contents of living cells, might account, at least in part, for the unbalance which exists between the solutions and the contents of the epithelial cells of the cornea.

The amino acids, with their complex structure, protein origin and presence in living cells, combined with their nutritive value, seemed ideal for use as a starting point. I investigated the commercial sources of amino acids and their availability and cost at each source. Pure individual amino acids are expensive, and the amounts available are limited. Fortunately, this investigation revealed the existence of "parenamine"<sup>1</sup> N N R, a commercially available preparation of a mixture of

<sup>1</sup> Manufactured by Frederick Stearns & Company Division, Detroit

amino acids "Parenamine" is a 15 per cent solution of amino acids, derived from the acid hydrolysate of casein. It contains all the amino acids known to be essential to man, plus other amino acids native to casein, which is a protein of high biologic value. "Parenamine" contains no protein polypeptides or other larger protein fragments which might be allegenic. Hydrolysis splits the protein molecule and destroys the biologic specificity of proteins. Amino acids themselves are not allergens.

Because of the acidity of "parenamine," any useful formulas had to contain alkaline salts to bring the mixture to a  $p_H$  of 8.0 to 9.0. It was natural to use the inorganic alkaline salts used for experimental work on inorganic solutions for use with contact lenses which were present in quantity in the laboratory. Sodium bicarbonate, potassium bicarbonate and sodium phosphate were shown experimentally to be too weakly alkaline for use. Solutions of sodium borate with "parenamine" and of sodium carbonate with "parenamine" were produced with a variety of osmotic pressures. These solutions could be worn one to two hours longer than any of the inorganic solutions but were discarded because of the formation of precipitates on standing.

Attention was next turned to potassium carbonate, in combination with "parenamine," with the basic formula

"Parenamine"	20.0 cc
Distilled water	80.0 cc
Potassium carbonate	1.4 Gm
"Phemerol chloride"	2.0 cc

The solution has a  $p_H$  of 8.2, a refractive index with sodium light ( $N_d$ ) of 1.3387 and an osmotic pressure of 1.4 per cent sodium chloride. No precipitate was formed on standing. A variety of solutions with increasingly stronger osmotic pressures can be made by varying the percentages of "parenamine" and potassium carbonate. The  $p_H$  can be controlled between 8.0 and 8.8, which is desirable. In repeated tests, this series of solutions could be worn two to three hours longer than those composed solely of inorganic salts.

It must be concluded, therefore, that the addition of amino acids to solutions for use with contact lenses lengthens the time that I can wear them and that further investigation is warranted. These solutions are perfect culture mediums and are easily and quickly contaminated. No satisfactory sterilization for an opened bottle has been found.

*Problem 5 Use of Methyl Cellulose in Solutions for Use with Contact Lenses*—The use of methyl cellulose in contact lenses was suggested verbally to me in 1944 by Mr. C. A. Oclassen, of the Westwood Chemical Company, and later an article appeared in the ARCHIVES suggesting its use not only in solutions to be worn with contact lenses,

but in other ophthalmic solutions<sup>2</sup> Methyl cellulose has a twofold advantage. It has a wetting property with optical plastics and a lubricating and soothing effect, due to its viscosity.

Using a 4,000 centipoise pharmaceutical grade of methyl cellulose, a series of aqueous solutions were made to test its wetting property, with the following results:

% Solution	Results
0.001	Unsatisfactory
0.01	Fair
0.1	Good
0.25	Very good

Next, a series of solutions of methyl cellulose were made to determine the relative viscosity and practicability for use with solutions for contact lenses. The results were as follows:

Solutions, %	Results
2	Much too viscous
1	Too viscous
0.5	Viscous enough to stick to eyelashes
0.25	Satisfactory viscosity
0.1	Viscous enough for solutions in contact lenses

In view of the foregoing information, it was decided that a methyl cellulose content of 0.1 to 0.2 per cent should be used in the previously mentioned solution of "parenamine" for contact lenses. A typical formula is as follows:

"Parenamine"	30 cc
0.2 per cent methyl cellulose solution	70 cc
Potassium carbonate	2 Gm
"Phemerol chloride" (1:1,000)	2 cc

This solution has an osmotic pressure of 2.037, a  $p_H$  of 8.6 and a  $N_d$  of 1.342. A whole series of solutions with varying osmotic pressures can be prepared by varying the percentage of "parenamine" or the percentage of potassium carbonate or both. The methyl cellulose does not affect the osmotic pressure.

The wearing time before clouding takes place is longer than that with any other solutions I have used. The wearing time with this series varied according to the osmotic pressure, as indicated in table 5. Clearness of vision is also lengthened because of the continued wetting property of the added methyl cellulose. It neutralizes the effect of the deposited sebaceous material from the lid margins, which becomes troublesome in some cases.

It can be concluded from the evidence that the addition of methyl cellulose increased the wearing time, at least for me, with a "parenamine"—potassium carbonate solution.

<sup>2</sup> Swan, K. C. Use of Methyl Cellulose in Ophthalmology, Arch. Ophth. 33:378-380 (May) 1944.

## COMMENT

I do not offer the data in this paper as a solution of the problem of clouding of the cornea by solutions worn with contact lenses. It is offered only as an addition to the very small amount of experimental work which has been done on this problem. Much remains to be accomplished. Other organic components of living cells must be investigated. The minimum amounts of these substances which are effective and the prevention of contamination by fungi and bacteria will have to be determined.

Progress has been made, as table 6, listing my wearing times for these solutions, positively indicates.

TABLE 6—*Wearing Times for Various Solutions in Contact Lenses*

Solution	Osmotic Pressure	Wearing Time Before Clouding
1.4% sodium chloride	1.4	1 hr 45 min
2.0% sodium bicarbonate	1.44	1 hr 50 min
1.4% sodium chloride and oxygen	1.4	2 hr
Sodium borate-boric acid buffer	1.4	2 hr
2.0% sodium bicarbonate and oxygen	1.44	2 hr 10 min
2.3% potassium bicarbonate	1.4	2 hr 15 min
"Parenamine" and sodium borate	1.4	2 hr 30 min
"Parenamine" and sodium carbonate	1.4	3 hr
"Parenamine," sodium carbonate and methyl cellulose	1.4	3 hr 15 min
"Parenamine" and potassium carbonate	1.4	3 hr 30 min
"Parenamine," potassium carbonate and methyl cellulose	1.4	3 hr 40 min
"Parenamine," potassium carbonate and methyl cellulose	1.74	3 hr 45 min
"Parenamine," potassium carbonate and methyl cellulose	2.037	4 hr 50 min
"Parenamine," potassium carbonate and methyl cellulose	2.375	5 hr

## SUMMARY

The addition of carbon dioxide to solutions for use with contact lenses did not affect the time in which corneal clouding occurs.

The addition of oxygen to solutions for use with contact lenses did not materially increase the time before clouding takes place.

Solutions for use in contact lenses with osmotic pressures as high as 2.8 per cent sodium chloride can be worn if the pressure is progressively increased.

Osmotic pressure is important in solutions for use in contact lenses.

The addition of amino acids to solutions for use with contact lenses increases the time before clouding of the cornea occurs.

The addition of methyl cellulose to solutions for use with contact lenses increases the time before clouding of the cornea occurs.

49 East Fifty-First Street

# SPONTANEOUS LUXATION OF THE EYEBALL

G LESLIE MILLER, M D

Chief of Staff, Department of Ophthalmology, City Hospital

ABRAHAM SCHLOSSMAN, M D

Resident in Ophthalmology, City Hospital

AND

WILLIAM H BOYD, M D

Resident in Ophthalmology, City Hospital

CLEVELAND

SPONTANEOUS luxation of the eyeball is so uncommon that few ophthalmologists have had the opportunity to study the condition closely, and the few who have had such an opportunity have often failed to determine a causative factor. Such a case was recently studied at this clinic.

## REPORT OF A CASE

A Negro woman aged 42, who was extremely obese, was admitted to the hospital with both eyes taped tightly shut. She stated that four years ago a sharp pain had developed in the right eye, the eye became proptosed and finally popped out of the socket. The globe was replaced by a physician, who instituted a course of anti-syphilitic therapy and prescribed a reducing diet. When on this regimen, she lost approximately 40 pounds (18.1 Kg). She had no further trouble until December 1945, when she again began to gain weight. At this time she had frontal headaches, which were severest at night. In May 1946 she noticed that the right eye was again prominent and experienced spontaneous luxation of the globe one evening when she was not exerting herself. The eye was replaced by a physician, but luxations occurred several times during the ensuing week. She finally taped both eyes shut, leaving only a small fissure to see through. In June 1946 the left eye began to bulge, and she was fearful that spontaneous luxation of that eye would occur.

Her history revealed no illnesses except for malaria, contracted as a child and never treated, and syphilis, which had been partially treated six months prior to her admission to the clinic of this hospital. The urine was normal, the red cell count was 4,500,000 and the white cell count 10,000, with a normal distribution of cells, the hemoglobin was 14 Gm per hundred cubic centimeters of blood, and the red blood cells and platelets appeared normal on smear. With exercise, the blood pressure varied from 104 systolic and 70 diastolic to 170 systolic and 90 diastolic. Roentgenograms of the chest and skull were normal, with the size and contour of the sella turcica within normal limits and the pineal gland not visible. The Kline diagnostic and exclusion tests gave negative reactions. The urea nitrogen of the blood measured 7.7 mg, sugar, 82 mg, total proteins, 7.6 Gm, albumin, 3.8 Gm, globulin, 3.8 Gm (albumin-globulin ratio, 1.01), calcium, 10.6 mg, inorganic





Fig 1—Photographs of the patient with obesity and spontaneous luxation of the eyeball. The eyes were taped shut on her admission.

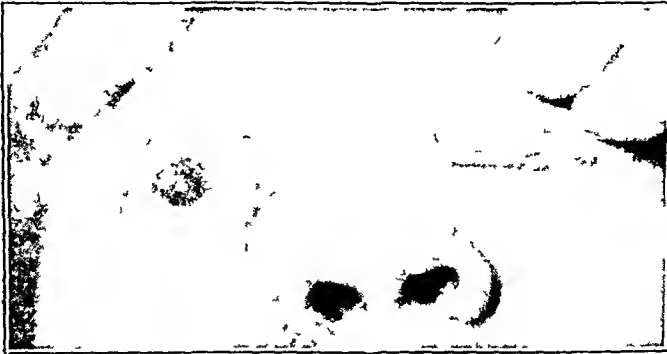


Fig 2—Spontaneous luxation of the right eye.

phosphate, 32 mg, and phosphatase, 67 units per hundred cubic centimeters. The cholesterol level decreased from 274 to 199 mg per hundred cubic centimeters in seven days under treatment with thyroid. The basal metabolic rate varied from +16 to +29 per cent on successive days. A 1,000 calory diet was instituted, as her weight was 286 pounds (130.6 Kg).

With 100 mg of merperidine hydrochloride N N R ("demerol hydrochloride") for sedation, the right eye was allowed to subluxate spontaneously for study. The globe protruded approximately 8 mm beyond the external bony edge of the orbit. Fundusoscopic studies showed a normal condition, but visual acuity was not determined, owing to the patient's complaints of the pain. Moderate exophthalmos was noted after the eye was replaced, and the patient complained of tinnitus in the right ear.

#### COMMENT

Woods<sup>1</sup> stated that the basic cause of the disturbance in the lid closure-opening apparatus of patients with primary toxic diffuse goiter probably lies in the increased instability of the sympathetic nervous system, a sympathicotonia, together with certain reflex relaxations or contractions of the voluntary muscle, the exact nature of which is not clear, but which may or may not be related to pressure by the exophthalmic globe. Woods also stated that he did not consider the sympathicotonia or thyrotoxicosis related to the exophthalmos itself.

In his recent article on this condition, Means<sup>2</sup> stated that the ocular picture is a local manifestation of a fundamental, generalized disturbance of water and electrolyte metabolism. On the other hand, the diminished secretion of normal thyroxin may have an irritating effect on the anterior lobe of the pituitary gland and allow overproduction of a hypothetic hormone acting on the orbital contents. However, the exophthalmos of exophthalmic ophthalmoplegia is probably quite different from the exophthalmos of primary toxic diffuse goiter, being produced by organic changes in the orbit, actual hyperplasia of the orbital contents and hypertrophy of the extraocular muscles, whereas the exophthalmos of primary toxic goiter is produced by edema of the periorbital tissues.<sup>3</sup>

A review of the literature reveals 25 cases recorded with the following etiologic diagnoses: gumma, 2 cases, extreme exophthalmic goiter, probably exophthalmic ophthalmoplegia, 4 cases, cerebellar tumor, 1 case, insanity, 2 cases, exophthalmos without goiter, 3 cases, cause unknown, 8 cases, bifurcated superior oblique muscle with two inferior

1 Woods, A. C. Ocular Changes of Primary Diffuse Toxic Goitre, *Medicine* **25** 113-153, 1946.

2 Means, J. H. Diagnosis and Treatment of Hyperthyroidism, *Canad. M. A. J.* **43** 509-513, 1940.

3 Marine, D., in discussion on Aird, R. B. Experimental Exophthalmos and Associated Myopathy Induced by Thyrotropic Extract, *Arch. Ophth.* **24** 1167-1178 (Dec.) 1940.

oblique muscles, 1 case, and spontaneous luxation due to shallow orbit in a deformed skull, including oxycephaly, 4 cases <sup>4</sup>

Fowler <sup>4a</sup> classified cases of luxation of the eyeball under four types (1) spontaneous luxation, arising from (a) oxycephaly, brachycephaly or related conditions due to premature synostosis, (b) exophthalmos, especially in Negroes and (c) exophthalmic goiter, (2) voluntary luxation, usually found in mentally subnormal Negroes, and probably due to a protractor action on the oblique muscles, (3) self-induced luxation, occurring in persons with mental disease, and (4) traumatic luxation, in which the globe is luxated but not avulsed

By the type associated with exophthalmic goiter, we assume he means the syndrome referred to by many authors as exophthalmic ophthalmoplegia, and it is under this head that we prefer to place our case. It was decided to try resection of Muller's muscle, together with tarsorrhaphy and subsequent decompression of the orbit, if necessary. However, the patient signed her release and was discharged. It is hoped that we shall be able to follow this patient and gain more insight into the endocrine imbalance which produces such extreme ocular changes.

City Hospital

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4 (a) Fowler, J. G. Spontaneous Luxation of the Eyeball. Report of Instance in Brachycephalic Patient, *J. A. M. A.* **116** 1206-1208 (March 22) 1941. (b) Ferrer, H. Voluntary Propulsion of Both Eyeballs, *Am. J. Ophth.* **11** 883-886, 1929. (c) Mertins, P. Subluxation of Eyeball, *ibid.* **5** 290-292, 1922. (d) Oertel, T. E. *ibid.* **3** 814-816, 1920.

# Clinical Notes

## DIAGNOSTIC MUSCLE CHART FOR DETERMINATION OF TROPIAS, PHORIAS, DIPLOPIA AND MUSCLE ACTION

ANTHONY AMBROSE, M D  
NEWARK, N J

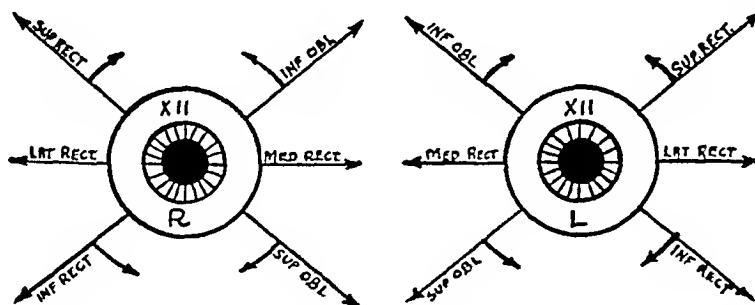
The accompanying chart is presented for use in the determination of tropias, phorias, diplopia and extraocular muscle action

<p>Up to Right</p> <p>R eye higher— 1 overacting</p> <p>RSR or oblique</p> <p>L eye higher— 1 overacting</p> <p>L I oblique or 2 weak RSR</p>	<p>Straight Up</p> <p>R eye higher— 1 overacting</p> <p>RSR or</p> <p>L eye higher— 1 overacting</p> <p>LSR or 2 weak RSR</p>	<p>Up to Left</p> <p>L eye higher— 1 overacting</p> <p>LSR or oblique</p> <p>R eye higher— 1 overacting</p> <p>Rt I oblique or 2 weak LSR</p>
<p>Directly Right</p> <p>Rt does not move enough— weak RER</p> <p>L moves too much—overacting LIR</p> <p>L does not move enough— weak LIR</p>	<p>Straight Ahead</p> <p>Eye in Con squint</p> <p>Eye out Div squint</p> <p>Determine fixing eye</p>	<p>Directly Left</p> <p>L does not move enough— weak LER</p> <p>R moves too much—overacting RIR</p> <p>R does not move enough— weak RIR</p>
<p>Down and Right</p> <p>R eye higher— 1 overacting</p> <p>LS oblique or 2 weak Rt Inf R</p> <p>L eye higher— 1 overacting</p> <p>R Inf R or 2 weakness of</p> <p>LS oblique</p>	<p>Directly Downward</p> <p>Rt eye higher— 1 weak R Inf</p> <p>Rect or L Inf Rect</p> <p>L eye higher— 1 weak L Inf</p> <p>rectus or R Inf Rect</p> <p>2 overacting</p>	<p>Down and Left</p> <p>R eye higher— 1 weak Rt</p> <p>Sup oblique or L Inf Rect</p> <p>L eye higher— 1 overacting</p> <p>Rt Sup oblique or 2 weak L Inf Rect</p>

Red glass in front of right eye

<p>Pts Right</p> <p>Red above—RSR</p> <p>Green or white above —LIO</p>		<p>Pts Left</p> <p>Green or white above —LSR</p> <p>Red higher—RIO</p>
<p>Red to R—RER</p> <p>Green or white to R —LIR</p>		<p>Green or white to L —LER</p> <p>Red to L—RIR</p>
<p>Red lower—R Inf R</p> <p>Green or white lower —LSO</p>		<p>Green or white lower —L Inf R</p> <p>Red lower—RSO</p>

Green glass or none in front of left eye



Diagnostic muscle chart for determination of anomalies of the extraocular muscles

## LOCAL USE OF "SULFAMYLON" (PARA-[AMINOETHYL]-BENZENE SULFONAMIDE HYDROCHLORIDE)

WILLIAM B. CLARK, M.D.  
NEW ORLEANS

In the summer of 1946 my colleagues and I experienced considerable trouble with infections due to *Bacillus pyocyaneus* (*Pseudomonas aeruginosa*) as secondary contaminations with our surgical dressings. Although we tried many preparations and various procedures to control the contamination, none proved particularly successful. We finally had a case in which an infection with *B. pyocyaneus* invaded the inside of the eye after an operation for cataract and the eye was lost.

About this time we heard of "sulfamylon"<sup>1</sup> (para-[aminoethyl]-benzene sulfonamide hydrochloride), which was said to be suitable for ophthalmic use. The preparation was available in both 1 and 4 per cent solutions, buffered with citrate to a  $p_H$  of 6.5.

"Sulfamylon" is a sulfonamide compound with a wide range of antibacterial activity, but, unlike most of these drugs, it is not inhibited by paraaminobenzoic acid. It has, therefore, proved effective in the presence of pus and blood. For example, Beyer<sup>2</sup> treated a series of 60 patients with fresh wounds using the substance (known in Germany as "marfanil") as a prophylactic against infection, and 140 patients with infected wounds using it as an antiseptic. The results were almost uniformly successful, and Beyer concluded that the drug was a valuable aid in the treatment of wounds.

More recently, Howes and his associates<sup>3</sup> reported on a comparative study of "sulfamylon," calcium penicillin, parachlorophenol, tyrothricin and zephiran chloride with regard to efficacy, speed of action and toxicity. For local chemotherapy they found that "sulfamylon" was superior to the others, that it possessed the widest range of antibacterial activity and that it was relatively nontoxic.

On Oct. 1, 1946, we began using "sulfamylon" to irrigate the conjunctival sac and to saturate eye pads used for dressings. Since then we have used it in 84 successive surgical cases, and in no instance have we had a case of contamination with *B. pyocyaneus*. Moreover, there has been no drug reaction in the lids. A few of the patients, it is true,

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From the Department of Ophthalmology, Tulane University of Louisiana School of Medicine.

1 The product was obtained through the courtesy of Winthrop Chemical Company, Inc., New York.

2 Beyer, W. *Zentralbl. f. Chir.* **68**: 1730, 1941, abstracted, *War Med.* **4**: 121 (July) 1943.

3 Howes, E. L. *Surg., Gynec. & Obst.* **83**: 1, 1946. Local Chemotherapy of Wounds, editorial, *J. A. M. A.* **132**: 333 (Oct. 12) 1946. Howes, E. L. *Ann. Surg.* **124**: 268, 1946.

have been exposed to the drug for only three or four dressings, but most of them are patients with cataract who have had dressings changed daily for seven or eight days. There were 5 cases of retinal detachment in which dressings were changed every other day. Each new dressing was applied moistened with 1 per cent "sulfamylon." This treatment was continued for a month after operation. In none of these cases did we have any of the reactions to the drug which we have experienced with other sulfonamide preparations, such as sulfathiazole.

It is also worthy of note that in no instance was there any pain, redness or irritation from irrigating the conjunctival sac with 1 per cent "sulfamylon." We have not used the 4 per cent solution for a sufficiently long period to determine whether it also is nonirritating. It appears at present that the 1 per cent solution is sufficient to control contaminations with *B. pyocyaneus*.

1430 Tulane Avenue (13)

# News and Notes

EDITED BY DR W L. BENEDICT

## GENERAL NEWS

**Annual Postgraduate Course, Oregon Academy of Ophthalmology and Otolaryngology**—The Oregon Academy of Ophthalmology and Otolaryngology has announced its ninth annual spring postgraduate course in ophthalmology and otolaryngology, to be held in Portland, March 21 to 26, 1948. The program for this course is arranged by the Oregon Academy and the University of Oregon Medical School.

In ophthalmology, the guest speakers will be Dr Albert D Ruedemann, professor of ophthalmology at Wayne University College of Medicine, Detroit, and Dr C Allen Dickey, associate clinical professor of ophthalmology at the University of California Medical School, San Francisco.

In otolaryngology, the guest speakers will be Dr French K Hansel, associate professor of otolaryngology at Washington University School of Medicine, St Louis, and Dr James H Maxwell, professor of otolaryngology at the University of Michigan Medical School, Ann Arbor.

The course consists of a series of lectures, clinical demonstrations and ward rounds. In order to be able to stress the practical demonstrations, the course will be limited to a total of 125. Any one interested should contact Dr Harold M U'Ren, secretary, 1735 North Wheeler Avenue, Portland 12, Oregon.

**Rivista di oftalmologia Founded**—Florentine ophthalmology, more or less stagnant since the transfer of *Bollettino d'oculistica* to Rome, and as a result of the recent war is undergoing a reawakening. Prof Biagio Alajmo, director of the Institute of Clinical Ophthalmology of the University of Florence, has founded a new monthly journal in ophthalmology, *Rivista di oftalmologia*, which appeared in January 1946 and is published by L Salpientia Florence, Italy.

The editor of the *Rivista* is ably assisted by a group of well known Italian ophthalmologists—V Accardi, A Bencini, G B Bietti, F Caramazza, D Cattaneo, V Cavaia, A Contino, Q di Marzio, E Federici, R Gallenga, L Guglianetti, G Lo Cascio, L Maggiore, V Rossi, A Santonastaso, S Sgroso, A Rubino, M Simonelli, and U Azzolini. The *Rivista* includes in its pages original papers, reviews, therapeutic notes and abstracts from Italian and foreign journals.

Volume 1 contains excellent papers by many prominent Italian ophthalmologists. If this volume is a portend of the future, it is safe to say that *Rivista di oftalmologia* will make an enviable reputation in Italian ophthalmologic literature. American ophthalmologists greet this newcomer with best wishes for its continued success.

**Eye Bank in New Orleans**—An affiliated "eye bank" has been organized in New Orleans which will have the cooperation of the

Louisiana State University School of Medicine and the Tulane University of Louisiana School of Medicine and Hospital

The new eye bank is located in the Hutchinson Memorial Building, New Orleans, and Mrs Oville Ewing is serving as executive director. The officers are Charles E Fenner, president, Dr William B Clark, first vice president, George L Hardin, second vice president, John F Reilly, treasurer, and John W Sims, secretary.

**Dedication of Thigpen-Cater Eye Hospital**—The Thigpen-Cater Eye Hospital, commemorating Dr Charles A Thigpen and Dr Job T Cater, was dedicated on November 2 at Birmingham, Ala. Dr Alston Callahan has been named director of the hospital.

**International Organization Against Trachoma**—The International Organization Against Trachoma (I O A T) was founded officially by decision of the Thirteenth International Congress of Ophthalmology, at its meeting at Amsterdam in 1929. It provides a society at the meetings of which matters of scientific, therapeutic and international interest connected with trachoma may be discussed.

The last general assembly of delegates and members was held in London on April 21, 1939. The proceedings were reported in *Revue internationale du trachome* for July 1939 and in the *British Medical Journal*.

A meeting of the executive committee of the organization was held in Paris on May 17, 1947, at 66 Boulevard Saint-Michel. There were present Dr MacCallan, president, Dr Wibaut, secretary general, Professor Nordenson, president of the International Congress of Ophthalmology, Dr Ehlers, secretary general of the International Congress of Ophthalmology, Dr Bailhart, president of the International Association for the Prevention of Blindness, Dr Lavery, Eire, and Dr Churchill, secretary adjoint of the International Association for the Prevention of Blindness. The accounts were scrutinized and passed as correct, and it was decided to hold the next general assembly of delegates and members and the scientific meeting in London in 1950.

The quarterly journal, *Revue internationale du trachome*, which is published in French and in English, is the official organ of the organization. Publication ceased during the war, but it is hoped that it will be resumed shortly. Articles by members of the organization may be sent to Dr Jean Sédan, 94 rue Sylvabelle, Marseille, France, secretary general of *La Ligue contre le trachome*, editor of *Revue internationale du trachome*.

Membership in the International Organization Against Trachoma is by an annual subscription of 25s sterling, this may be paid to the account of the organization at the National Provincial Bank, 23 Wigmore Street, London, W 1. Larger donations from ophthalmologic societies are invited for the purpose of meeting the general expenses of the organization.

If circumstances permit, *Revue internationale du trachome* will be posted to members as published.



Further information may be obtained from the president, A F MacCallan, Westminster Hospital Medical School, 17 Horseferry Road, London, S W 1, or from the secretary-general, F Wibaut, P C Hooftstraat 145, Amsterdam, Netherlands

#### UNIVERSITY NEWS

**Refresher Course in Ophthalmology and Otolaryngology, University of Toronto**—The University of Toronto Faculty of Medicine announces a refresher course in the combined subjects of practical ophthalmology and otolaryngology from January 26 to 31, 1948. The course will be so arranged that the operative procedures and bedside conferences of the one specialty will be held in the morning and the didactic conferences or lectures in the afternoons. The reverse of this procedure in the other specialty will make it possible for each applicant to pick whatever subjects may be of interest to him. A full program will be published later and will also be available on application to the Medical Office, University of Toronto. The fee for the course is \$50. The course will be given for a minimum of ten students and a maximum of twenty students.

**Midwinter Seminar in Otolaryngology and Ophthalmology**—In 1948 the University of Florida Midwinter Seminar in Otolaryngology and Ophthalmology will be held at the Flamingo Hotel, Miami Beach, beginning on January 12 and continuing through January 17. The lectures in otolaryngology will be presented on January 12, 13 and 14 and those in ophthalmology on January 15, 16 and 17. The registration fee is \$25.

The distinguished lecturers for the courses in otolaryngology include Dr Lawrence R Boies, Minneapolis, Dr Louis H Clerf, Philadelphia, Dr Kenneth M Day, Pittsburgh, Dr Thomas C Galloway, Chicago, Dr James H Maxwell, Ann Arbor, Mich, Dr Arthur W Proetz, St Louis, and Dr Harry P Schenck, Philadelphia. Among the outstanding ophthalmologists who will lecture are Dr S Judd Beach, Portland, Me, Dr William L Benedict, Rochester, Minn, Dr Daniel B Kirby, New York, Dr Peter C Kronfeld, Chicago, and Dr Dohrmann K Pischel, San Francisco.

The Midwinter Seminar follows immediately the Pan-American Congress of Ophthalmology, which will be held in Habana, Cuba, Jan 5 to 10, 1948. The dates chosen for the two meetings make possible a delightful opportunity to attend both and at the same time to enjoy a winter vacation amid unsurpassed resort attractions.

**The University of Florida Midwinter Seminar in Otolaryngology and Ophthalmology**—The seminar in 1948 will be held at Miami Beach, Fla. The courses in ophthalmology will be given on January 15, 16 and 17. The lecturers will be Dr S Judd Beach, Portland, Me, Dr William L Benedict, Rochester, Minn, Dr Daniel B Kirby, New York, Dr Peter C Kronfeld, Chicago, and Dr Dohrmann K Pischel, San Francisco.

Application should be made to Dr Walter T Hotchkiss, Miami Beach, Fla.

## SOCIETY NEWS

The Research Study Club of Los Angeles announces its seventeenth annual midwinter postgraduate clinical convention in ophthalmology and otolaryngology on January 19 to 30, 1948

January 19 to January 24 will be given over to the section on ophthalmology. The principal speakers will be Dr Francis Heed Adler and Dr Harold Glendon Scheie, who will speak on the University of Pennsylvania's "school of thought" in ophthalmology, Dr Phillips Thygeson, of San Jose, Calif, and Dr Meyer Wiener, Coronado, Calif

It is well to write for an early reservation to Mr H M Nickerson, manager of the Elks Club, Parkview at Sixth Street, Los Angeles 5. In order to shorten the time of registration, it is suggested that the fee for the clinical courses, \$75, be sent in advance to Pierre Violé, M D, treasurer, 1930 Wilshire Boulevard, Los Angeles 5

**Conference of the National Society for the Prevention of Blindness, Inc.**—The National Society for the Prevention of Blindness, Inc, announces that it will hold a three day conference April 5, 6 and 7, 1948, at the Hotel Radisson, Minneapolis. This conference will be of interest to persons who are directly or indirectly concerned with ocular health and safety. Details concerning the program may be obtained by writing directly to the Society, 1790 Broadway, New York 19

## PERSONAL NEWS

**Dr. Culler Appointed Chairman of Department of Ophthalmology, Ohio State University School of Medicine**—Dr Arthur M Culler, a member since January 1946 of the staff of the department of ophthalmology of Ohio State University College of Medicine, Columbus, Ohio, has been elected chairman of the department, to succeed the late Dr Albert D Frost. Dr Claude S Perry has been acting chairman and will now continue as associate professor.

Dr Culler received his degree of Doctor of Medicine at the University of Michigan Medical School in 1926, from 1928 to 1930 he served as instructor in ophthalmology at the University of Michigan and also held the John E Weeks scholarship in ophthalmology during that period. During World War II he served in the South Pacific as a captain in the naval reserve.

**Dr. Daniel B Kirby Completes Lecture Tour in South America**—Dr Daniel B Kirby, of New York, has recently returned from a good will lecture and conference tour of South America, under the auspices of the Pan-American Association of Ophthalmology. He visited Rio de Janeiro and São Paulo, Brazil, Montevideo, Uruguay, Buenos Aires, Rosario and Cordoba, Argentina, Santiago, Chile, and Lima, Peru. In all countries, Dr Kirby found the oculists receptive and cordial. Many plan to attend the third Pan-American Congress of Ophthalmology in Cuba, January 4-10, 1948 and to visit the United States directly before or after the congress.

# Abstracts from Current Literature

EDITED BY DR WILLIAM ZENTMAYER

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## Anatomy and Embryology

PROBLEM OF THE INSERTION OF THE OBLIQUE MUSCLES AROUND THE MACULA E P FORTIN, Arch de oftal de Buenos Aires 20: 295 (July-Aug ) 1945

Fortin suggests that the special anatomic and histologic architecture of the superior and inferior oblique muscles may have some bearing on a specialized function of the movements of the eyes, particularly in fixation. He stresses the fact that the insertion of these muscles in the sclera around the region of the macula is not well demonstrated by ordinary dissection. Microscopically it may be observed that many fibers of the muscle are inserted beyond the limits established by the dissecting knife.

He concludes that the oblique muscles encircle the macula and act on it. The article is illustrated with numerous photomicrographs.

H F CARRASQUILLO

## Aqueous Humor

CHOLESTEROL IN THE ANTERIOR CHAMBER J M ICAZA Y DUBLAN, Bol Hosp oftal de Nuestra Sra de la Luz 3: 143 (March-April) 1946

A case of deposits of crystals of cholesterol in the anterior chamber of the right eye of a woman aged 40 is reported. The eye was blind, presumably due to a preexisting intraorbital inflammatory condition. One morning, after a cold bath, she had to cook on a wood range and received heat in her face. In the afternoon, after she had had an attack of severe pain in the eye, her relatives noticed a white spot. Examination revealed degeneration and atrophy of the iris, a posterior synechia and a pupillary membrane. The lower half of the anterior chamber contained a whitish mass, which was formed of small, glistening bodies. Similar bodies were also seen floating in the aqueous. With the slit lamp, numerous, typically colored crystals of cholesterol were observed forming the mass and floating in the aqueous, simulating a shower of diamonds.

According to the author, precipitation of the cholesterol crystals was brought about by the abrupt changes in temperature to which the patient's diseased eye was subjected.

H F CARRASQUILLO

## Conjunctiva

SULPHAPYRIDINE-RESISTANT KOCH-WEEKS [INFLUENZAL] CONJUNCTIVITIS H J STERN, Brit J Ophth 30: 722 (Dec ) 1946

During the past four years Stern has seen a considerable number of East African Negroes in military hospitals in the Middle East. The result of treatment of conjunctivitis due to *Hemophilus influenzae* (Koch-

Weeks bacillus) with sulfapyridine has been so disappointing in these patients that it had to be given up and the old-fashioned use of silver nitrate reinstated. The failure of sulfapyridine can be explained by the existence among these people of a sulfonamide-fast strain of *H. influenzae*. The possibility suggests itself that sulfapyridine-resistant strains of *H. influenzae* are harbored by carriers who themselves have only a mild chronic conjunctivitis but are in a position to infect others with it.

W. ZENTMAYER

VERNAL CONJUNCTIVITIS. P. J. ALVARADO, *Bol. d. Hosp. oftal. de Ntra. Sra. de la Luz* 3: 153 (May-June) 1946

Alvarado believes that vernal conjunctivitis is a syndrome to be incorporated into the symptomatic picture of the actinic-hypovitaminotic keratoconjunctivitis. Present day knowledge of vitamins reveals that two important disturbances originate in hypovitaminosis: endocrine disorders and disorders of the liver and skin or allergy. From the action of ultraviolet radiation, it is evident that physical, climatic and geographic causes contribute to modify the ocular symptoms of the hypovitaminoses, although one cannot state conclusively what effect the endocrine disorders and allergies caused by hypovitaminoses may or may not have on the ocular disturbances.

M. E. ALVARO

### Congenital Anomalies

RUBELLA AND CONGENITAL ABNORMALITIES. Editorial, *Brit. M. J.* 2: 778 (Nov. 23) 1946

There seems to be little doubt of the association between rubella during pregnancy and the subsequent birth of a child with a congenital abnormality. Two questions still remain: How frequently does the association exist? In what proportion of all children thus defective is rubella the cause? The authors cite a number of articles, principally from the American press, and give the following answer: First, rubella during the early months of pregnancy has something less than a 10 per cent chance of damaging the fetus, and, second, of all such congenital abnormalities in children, 5 to 10 per cent may have their origin in damage by virus during intrauterine life. This suggests a complete reexamination of the etiology of congenital defects. It is, however, abundantly clear that rubella itself does not provide the entire explanation and that many other extrinsic factors should be included in the range of inquiry.

ARNOLD KNAPP

### Cornea and Sclera

POSTERIOR RING ABSCESS OF METASTATIC ORIGIN IN BEHCET'S DISEASE. A. FEIGENBAUM and W. KORNBLUTH, *Brit. J. Ophthalm.* 30: 729 (Dec.) 1946

A case of posterior ring abscess occurring in a man aged 28 with Behcet's disease, a chronic septic condition produced by *Staphylococcus aureus* in a constitutionally predisposed person, is reported. Prior to the

development of the corneal complication there had been present recurrent uveitis and iriditis

W ZENTMAYER

SIMPLIFIED TREATMENT OF HERPETIC KERATITIS WITH ALCOHOL  
S LATORRE and G CRISPI, Arch Soc oftal hispano-am 6 54  
(Sept) 1946

The authors treated a series of 19 patients with herpetic keratitis with methyl alcohol. Of these patients, only 1 was resistant to the treatment, and he also proved resistant to the Gruter iodine treatment. The time required for cure averaged seven days, being in most cases only four or five days.

The technic used was as follows. After instillation of solutions of cocaine hydrochloride and fluorescein sodium, the application of alcohol was made with a small cotton applicator wet in 90 per cent alcohol, care being taken not to trespass beyond the areas of the lesions. The treatments were repeated every three days until no stain was obtained with the fluorescein. Usually one application was sufficient.

H F CARRASQUILLO

### Experimental Pathology

THE NEUROCAPILLARY TEST IN EXPERIMENTAL ANIRIDIA F VIDAL  
J L MILBRAN and J G BADARACCO, Arch de oftal de Buenos  
Aires 21 105 (April-June) 1946

The action of carbaminoylecholine chloride on cats with experimental aniridia and partial iridectomy is studied. This drug first rapidly reduces the ophthalmotonus in both eyes. The reduction is followed by a slow increase in both eyes, the effect, however, being much less in eyes which have been operated on. These reduced values are interpreted as being due to the decrease in the dialytic vascular area.

A bibliography is appended.

M E ALVARO

MALE SEX ORGANS AND INTRAOCULAR PRESSURE M RADNOT Ophth-  
thalmologica 107 282 (May-June) 1944

Imre contended that some cases of glaucoma seem to be linked with androgens, whereas Velhagen asserted that there is no such relationship and that castration is of no influence on the intraocular pressure. Radnot believes he has shown that castration produces hypotony in rabbits, which lasts for a short time. Strangely, unilateral castration caused hypotony in the contralateral eye. Ligation of the duct, which leads to atrophy of the testicular tissue, caused contralateral hypotony immediately, or in some cases pronounced variations in pressure, followed by hypotony. Irradiation of the testis also produced contralateral hypotony. Castration changes the relation of the intraocular pressure to injections of anterior pituitary. (The experimental data are not at all convincing [Reviewer].)

F H ADLER

## General

PRESENT DAY PLASTIC CONTACT LENSES E AMORETTI, *Ophthalmologica* 7: 287 (Oct-Nov-Dec) 1946

Amoretti considers three outstanding events in the development of plastic contact lenses the obtaining of correct impressions of the human eye with the use of "negocoll" (an elastic hydrocolloid), by Dallos, the employing of plastic material instead of optical glass, by Obrig, and the substitution of "moldite" (a derivative of alginic acid) for "negocoll," by Obrig

After commenting briefly on some of the papers presented at the first world conference on contact lenses, held in Chicago on Oct 13 1944, the author draws the following conclusions 1 The use of contact lenses is the best method for the exact correction of most errors of refraction 2 The widespread requirement for contact lenses can best be met at present by the molded plastic contact lens 3 The successful use of contact lenses depends largely on obtaining perfect impressions 4 The Anderson shell, used with the correct technic, provides the best impressions obtainable up to the present 5 When one is considering the technic of fitting, a matter of fundamental importance should be borne in mind, namely, that excessively tight areas cause loose areas, which is frequently productive of a corneal touch 6 Spherical and toric plastic contact lenses can be used with indisputable success in certain cases 7 When these two types of lenses are used successfully, it is not only the structure of the eye but also the fact that the lenses are of plastic material that makes the necessary fitting possible 8 In spite of the progress made, the important problem of appropriate ocular solutions has not yet been solved in an entirely satisfactory manner 9 Obrig's secret method for correcting induced astigmatism should be divulged 10 The ophthalmologist should fit contact lenses to patients with keratoconus

H F CARRASQUILLO

## General Diseases

RETINAL HEMORRHAGES ASSOCIATED WITH SENILE PURPURA AND GLAUCOMA WITHOUT HYPERTENSION E REDSLOB and A BRONNER, *Ann d'ocul* 179: 63 (Feb) 1946

The authors point out that the retinal complications of purpura are extremely rare, especially if one excludes scurvy and the purpura secondary to infection When hemorrhage does occur, it is usually orbital or subconjunctival ecchymosis Bateman, in 1835 described five forms of purpura, of which one was senile purpura He stated that this disease was limited to older women Dusky, irregular spots are to be seen on the dorsal surface of the forearm They last for ten to twelve days and disappear After this early description, Unna in 1896 and Pansini, in 1906 published reports on this condition Pansini added to the original description the observation that the disease did not occur unless there was evidence of senile atrophy of the skin The changes in the skin were the first symptom, the hemorrhages followed The general physical condition of the patient was unaltered and except for the condition of their skin they were in good health

The authors wish to point out that this condition may not be limited to the skin and that hemorrhages may occur in other tissues

The authors report in detail the case of a woman aged 74. When first seen, the patient had bilateral immature cataracts, as well as glaucomatous cupping of both nerve heads. The intraocular tension was subnormal. Cataract extraction was performed on the right eye and was complicated by a hemorrhage into the anterior chamber on the second postoperative day. Approximately two years later she was readmitted to the hospital, and it was on this admission that the purpura was noted. On this admission retinal hemorrhages were noted in the right eye. The intraocular tension was 15 mm of mercury. The patient was thoroughly studied, and the only positive finding was increased capillary fragility in the tourniquet test. After treatment with ascorbic acid for several days, the intracapsular extraction of the left eye was performed. On the second postoperative day a severe anterior and posterior hemorrhage occurred. This gradually cleared and the nerve head showed the typical glaucomatous cupping as noted in the opposite eye.

The authors believe that their patient had senile purpura, as described by Bateman. In addition, she had retinal hemorrhages and glaucomatous cupping of the nerve heads without increased intraocular pressure. They ascribe the retinal hemorrhages to transient increases in arterial pressure. The capillaries are fragile, and the loss of elasticity decreases their ability to withstand changes in arterial pressure.

From previous studies on glaucoma, they conclude that the atrophy and cupping of the nerve head are on a vascular basis. In the case reported the intraocular tension was below normal. The atrophy and cupping of the nerve head are therefore probably due to the loss of elasticity, as noted in the other structures, as well as a diminished blood supply, which occurs with hypotension.

P. R. McDONALD

DENTAL FOCAL INFECTION. J. R. SANCHEZ, Bol d Hosp oftal de Ntra Sra de la Luz 3:179 (May-June) 1946

Sanchez reaches the following conclusions. Knowledge of the existence of chronic dental foci and the lesions which they produce is of great importance both for the general practitioner and for the specialist. Immediate cure of the lesions is not always obtained after elimination of the foci, for often these foci are the result of a severe toxemia, which disappears slowly. When one is faced with an abnormal leukocytic formula, without specific cause, chronic foci should be thought of and roentgenograms taken of all the teeth. Greater collaboration of general practitioner, specialist and dentist is indispensable, as the modern surgeon dentist working in cooperation with the physician should play his part in preventing and curing serious diseases.

A bibliography is appended.

M. E. ALVARO

### Glaucoma

TREATMENT OF GLAUCOMA WITH NONPERFORATING CYCLODIATHERMY  
L. WEEKERS and R. WEEKERS, Bull. Belgian Soc. Ophth., 1945,  
no. 81, p. 50

The anesthesia is accomplished by the instillation of cocaine and epinephrine, with the retrobulbar injection of 1 cc. of a 4 per cent solu-

tion of procaine hydrochloride (scurocaine) In order to make the operation entirely painless, 1 cc of 40 per cent alcohol is injected five minutes after injection of the procaine The electrode is a small cylinder, 0.75 mm in diameter and 1 mm in height The lids are separated with the usual lid elevator The electrode is applied directly to the eyeball without dissection of the conjunctiva, with enough pressure to maintain contact The electrode is placed 7 mm from the limbus This is an important point Eight applications are made, and they are placed at regular intervals between the tendons of the rectus muscles, each application is made for fifteen seconds After the electrode has been withdrawn, there is a depression at the point of application The bulbar conjunctiva is perforated, and the hole is somewhat larger than the diameter of the electrode Around the margin there is a white halo from the coagulation and the ischemia of the surrounding conjunctiva At the depth of the depression one sees the normal sclera In order to avoid drying of the cornea, it is well to divide the operation into two or three stages and between each step to remove the speculum The after-treatment is simple, and a dressing is not necessary Atropine, 1 per cent, is instilled three times a day for three days during the phase of hypotony and as a preventive of posterior adhesions

The authors conclude as follows

- 1 Diathermization of the ciliary body has a definite hypotensive effect, which can be employed in the treatment of glaucoma This effect is due principally to vasodilatation of the uveal vessels, which influences the circulation of the aqueous and aids in its absorption There is in addition a certain amount of atrophy of the ciliary body, which will lead to continued reduction in the formation of aqueous humor and a decrease in the ocular tension

- 2 The operative technic produces diathermization of the ciliary body without perforating the sclera A point 7 mm from the limbus is in the region of the ora serrata, which is a zone without danger to the ciliary body Histologic examination has shown that the vascular condition produced by the diathermic action extends backward to the retina, while little action is exerted on the ciliary body, its processes and the iris Every part of the ciliary body is involved, even when a very narrow electrode is applied to the posterior limit of the ciliary body With application of the electrode nearer the limbus the hypotensive effect is greater, but is likely to cause iritis and cataract

- 3 With chronic or subacute glaucoma it is possible to reduce the ocular tension to within the physiologic level at one sitting This reduction is not generally as low as that obtained in the operation with entanglement of the iris If necessary, in order to increase the hypotensive effect, the nonperforating cyclodiathermy may be repeated after a definite interval If the choice is possible, the operation with entanglement of the iris is preferable to cyclodiathermy The latter, however, is of great value when other operations have proved inadequate

- 4 At the present time diathermy is not adaptable to treatment for acute glaucoma

- 5 With secondary glaucoma the hypotensive effect of cyclodiathermy will be less constant than with chronic glaucoma The result depends



on the condition which produces the hypertension. This procedure is especially useful when the hypertension occurs in a condition which is of itself capable of improvement, such as tuberculous uveitis. The non-perforating cyclodiathermy for such conditions permits the correction of the transitory hypertensive stage.

6 With painful absolute glaucoma nonperforating cyclodiathermy may replace the necessity of enucleation.

7 With infantile glaucoma the results of nonperforating cyclodiathermy are less favorable than those obtained with the operation with entanglement of the iris. Diathermy, nevertheless, is a useful treatment when the latter operation has shown itself to be inadequate.

8 Nonperforating cyclodiathermy, if it is correctly executed, has a remarkable anodyne action, much greater than the perforating cyclodiathermy of Vogt.

9 The technic may still be improved on. It is desirable to continue research on the means by which the tension of the glaucomatous eye may be reduced without injury to the eyeball.

ARNOLD KNAPP

#### PHYSIOLOGIC DRAINAGE OF THE INTRAOCULAR FLUIDS REESTABLISHED BY HEMICYCLODIALYSIS. A. TORRES ESTRADA, Bol. d. Hosp. oftal. de Nuestra Sra. de la Luz 3: 121 (March-April) 1946

The author establishes the existence of two fundamental stages in glaucoma, the one functional and the other degenerative. The functional stage is determined by hyperemic phenomena in the external and internal membranes of the eye. The degenerative period is ushered in by the beginning formation of the glaucomatous excavation of the papilla.

Torres Estrada is a fervent advocate of hemicycloclydialysis for glaucoma. The procedure is a classic cycloclydialysis which is extended half around the limbus. He has replaced the fistulizing operations with this type of intervention. According to him, the failures of this operation reported by other surgeons are due to the advanced stage of the disease in the eye at the time of operation. In cases in which the glaucoma has progressed to a considerable extent he accompanies the hemicycloclydialysis with iridectomy.

The generally accepted theory of the *modus operandi* of cycloclydialysis is that it establishes drainage of the aqueous humor into the suprachoroidal space. Against the procedure it is claimed that the passage opened by the operation is closed promptly by cicatrization and the drainage is thus of short duration. Torres Estrada's idea, which he has proved recently by histopathologic examination of the eyes of cadavers in which the operation had been performed and which were not in an advanced stage of glaucoma, is that with this operation the intraocular fluids are drained into the canal of Schlemm, as normally occurs. The disinsertion of the fibers of the ciliary muscle from the inner wall of the canal of Schlemm, which is formed chiefly by these fibers, and the opening of the meshes of the pectinate ligament by the operation reestablish the physiologic drainage of the intraocular fluids.

H. F. CARRASQUILLO

## Injuries

TRAUMATIC MYOPIA AND HYPERTONIA ROGER WEEKERS, *Ann d ocul* 178: 236 (June) 1945

The author presents the case of an 11 year old boy who was hit in the left eye. The patient was seen the day after the accident. There were hematoma of the lids, subconjunctival hemorrhage and edema of the retina with some fine hemorrhages. The anterior chamber of the injured eye was slightly shallower than that of the right eye. The lens was grossly normal, and examination with the slit lamp did not reveal any change. Vision in the left eye was improved to normal with a  $-3.50$  D sphere. The intraocular tension was very low on palpation. The patient was placed under treatment with atropine. In approximately one month vision was normal with a  $+1.00$  D sphere. The eye was injured again at this time. Vision and tension gradually returned to normal over a period of about six weeks.

The author does not believe that the myopia was caused by spasm of the accommodation, change in refractive index of the intraocular fluids or anterior displacement of the lens. He attributes the myopia to a relaxation of the zonule brought about by hyperemia and edema of the ciliary body and the hypertonia to an increased absorption of the aqueous

P. R. McDONALD

REVIEW OF CONTRIBUTIONS OF WORLD WAR II TO OPHTHALMOLOGY  
RICHARD J. HESSBERG, *Ophthalmologica* 112: 292 (Oct-Nov) 1946

The author reviews more than two hundred papers from the ophthalmic literature from 1939 to 1945 and gives the following summary: 1. Most of the perforating ocular injuries resulted from mines and other explosives. 2. All injuries of the eye should be sent to the ophthalmologic departments as quickly as possible. At the first aid station only cleaning and dressing should be done. 3. The direct suture of corneal wounds is the method of choice. Widely gaping perforations need conjunctival flaps. 4. The multitude of foreign bodies and the majority of small non-magnetic fragments make the posterior route the method of choice for the extraction of intraocular foreign bodies. 5. Early enucleation of a blind eye is preferable to evisceration, which should only be done in case of true panophthalmitis. 6. Blast causes severe damage to the eyes. It may mean complete loss. 7. In injuries to the orbit only careful examination of its contents and roentgenograms will show the extent of the injury. For proper treatment medical teamwork is important.

F. H. ADLER

## Neurology

SIGNIFICANCE OF CORNEAL AND PHARYNGEAL REFLEXES IN NEUROLOGY AND PSYCHIATRY M. OSTOW and M. OSTOW *Arch Neurol & Psychiat* 55: 320 (April) 1946

In this paper, the distribution of variations in corneal and pharyngeal reflexes and their relations to other physical and mental signs are repre-

sented. The authors included in the study 141 patients—58 young men in various stages of acute psychoses and 83 maladjusted persons with a mental state just within the limits of psychiatric normalcy. The results of their study indicate that any patient who exhibits absence of corneal reflexes in the presence of an active pharyngeal reflex should be strongly suspected of having organic disease of the brain.

S. R. IRVINE

THE NERVE-FIBRE BUNDLE DEFECT. H. M. TRAQUAIR, Tr. Ophth Soc. U. Kingdom 64: 3, 1944

This paper was presented as the presidential address before the annual congress of the ophthalmological Society of the United Kingdom in 1944. The important anatomic points concerned were briefly reviewed. The term "nerve fiber bundle" in connection with the field defects described refers to any small group of fibers which lie together as they enter the papilla, although there is no anatomic segregation into such groups in the retina. Traquair summarizes these field defects as follows:

The nerve fiber bundle defect is a common type of field change associated with lesions of the visual pathway between the retina and the chiasm. It would probably be more frequently found with conditions with which it seems to be uncommon if it were more carefully looked for. It shows that fibers which lie close together in the retina remain close together at least as far as the chiasm. Such defects are produced in connection with pressure injury and inflammation, and possibly with vascular obstruction. No satisfactory explanation of their production in cases of glaucoma has yet been suggested. The presence of this type of defect in association with several pathologic conditions suggests that there must be a common causal factor. This suggestion is supported by the observation that the typical field defects of chiasmal lesions also show common features with different causes. The common factor is probably anatomic and concerned with the finer arrangement of the nutritive vascular supply to the fibers. It may be surmised that this principle holds good throughout the visual pathway.

The relative absence of straight nerve fiber bundle defects in the temporal fields is noticeable at every level from the retina to the chiasm except in cases in which the position of the lesion is fortuitous, as in those of juxtapapillary choroiditis or injury. The fact that such defects are less noticeable by the patient does not satisfactorily account for this peculiarity. In cases of vascular obstruction, and also of retinal angiodopathy, the vessels which surround the macular area are frequently affected, those on the nasal side are rarely involved. Is it possible that some condition of the vessels is the factor which links together all these conditions, including glaucoma and lesions of the optic nerve and chiasm? The absence of nerve fiber bundle defects with the toxic amblyopias supports the view that the field changes in some of these conditions at any rate, depend primarily on damage to the retinal cells rather than to the fibers.

W. ZENTMAYER

OCULAR NEUROCIRCULATORY ASTHENIA REPORT OF A CASE A GRAM-  
MATICO, Arch oftal de Buenos Aires 21: 97 (April-June) 1946

The author states that in many patients subjective symptoms are often improved after correction of refractive errors, others require in addition the removal of foci of infection. Even with this treatment some patients do not improve in spite of clinical attention and serologic tests. Many of these patients have ocular neurocirculatory asthenia, demonstrated by changes in the arteriovenous relation, narrowed visual fields, decreased ophthalmotonus, intolerance for the parasympathomimetic drugs and a hematic and somatic syndrome. Great improvement was obtained with instillations of a 5 per cent solution of sulfate of 1-phenyl-2-methylamine-propanol-1 (ephedrine sulfate), an acid diet and thyroid opotherapy. A control is kept by watching the visual fields, which show a surprising improvement. The ophthalmotonus remains unchanged.

A bibliography is appended

M E ALVARO

### Ocular Muscles

HETEROPHORIA—DIAGNOSIS AND TREATMENT EDWARD HARTMANN,  
Ann d'ocul 179: 71 (Feb ) 1946

The author was greatly impressed during his stay in the United States with the systematic way in which American ophthalmologists measured the ocular muscle balance. The purpose of this paper is to familiarize the French ophthalmologists with a simple routine to be followed and with how heterophoria should be treated.

The Maddox rod and screen and parallax tests are fully described, as well as the way in which the results should be tabulated. The author then describes the measurement of prism convergence and divergence. The results of the examination and the patients' symptoms are then evaluated. The routine use of prisms for the correction of heterophoria is deprecated. The author feels that some attempt at treatment—convergence exercises, use of loose prisms or orthoptic training—should be tried, especially in cases of the lateral phorias, before prisms are prescribed.

In cases of the hyperphorias exercises are of little benefit—here the prisms are usually prescribed to correct one half to two thirds of the vertical imbalance.

In selected cases surgical intervention may have to be considered

P R McDONALD

GLAUCOMATOUS IRIDOPLEGIA AND THE MIOSIS OF THE ARGYLL ROBERT-  
SON SYNDROME F VIDAL and M BRODSKY, Arch de oftal de  
Buenos Aires 21: 123 (April-June) 1946

The authors believe that the local metabolic alterations of the smooth cells of the iris can produce distinct alterations in the pupillary diameter, according to the cells attacked—miosis in the Argyll Robertson syndrome and mydriasis in acute glaucoma. A bibliography is included.

M E ALVARO

## ' Orbit, Eyeball and Accessory Sinuses

AN UNUSUAL CASE OF INTRA-OCULAR HEMORRHAGE D W McLEAN,  
Brit J Ophth 30:758 (Dec) 1946

A woman aged 43 had had blurring of vision in the left eye since the previous evening. The pupil was half filled with a bead of red blood about 3 mm in diameter. Dilation of the pupil showed a strand of pupillary membrane stretching roughly horizontally across the pupil. The hemorrhage proceeded from this strand, close to the temporal margin of the pupil, and extended forward in front of the margin. There was no history of trauma, but, as the patient had been playing with a boisterous child immediately before the onset, the occurrence of a minor injury seemed likely.

W ZENTMAYER

## Refraction and Accommodation

FREQUENCY OF ERRORS OF REFRACTION A J GONZALEZ, Arch  
chilenos de oftal 2 19 (Nov-Dec) 1945

The national statistics show that hyperopia is the most common error of refraction noted among the school children of Chile. The average percentage is 52.27. The hereditary factor is believed to be of importance from an etiologic viewpoint. The frequency of hyperopia is due to the high percentage of degrees under 3 D. Myopia occurs in 29.46 per cent. It is interesting to study the hereditary, constitutional and hormone deficiency factors in the young myopic patients, for these seem to be of greater importance than the mechanical causes (such as reading small print and incorrect body position), although the latter are, of course, of relative value.

A bibliography is appended.

M E ALVARO

## Retina and Optic Nerve

A MACULAR LESION OF UNDETERMINED ORIGIN REPORT OF FIVE  
CASES PIERRE HALBRÓN and ALEXANDRE ROZAN, Ann d'ocul  
179 131 (March) 1946

The authors report 5 cases of an interesting macular lesion noted in returning prisoners of war. The cases were all observed in the latter part of 1945. In each case the lesion was limited to the macula, the periphery of the fundus and the retinal vessels were within normal limits. The lesion was characterized by disappearance of the foveal reflex and an increase in redness of the macular region. In 1 case the lesion appeared somewhat like a "hole in the macula," but no difference in level was noted between the fovea and the surrounding retina. In another case faint lines through the macula gave it a wrinkled appearance. Around the macula in an area about the size of the nerve head the retina was slate gray. There was no evidence of any elevation, and at no time were any hemorrhages, exudates or edema noted. Visual acuity was reduced to from 1/10 to 6/10 in all cases. The lesion was binocular in 4 of the 5 cases.

Two of the patients had suffered injuries from blasts, while 3 had undoubtedly been undernourished. The authors think that the lesion may be due to a deficiency of some factors essential to health. There was no obvious vitamin deficiency, but all the patients observed had been prisoners of war.

The treatment employed was mercury and acetylcholine and was followed by some improvement.

P. R. McDONALD

CENTRAL SEROUS RETINOPATHY. H. ROCHA and B. GOMES, Brazil  
med 59.21 (April) 1945

The disease is briefly described. Six excellent case histories are given in detail, and the conclusion is reached that an allergic etiologic factor predominates, usually tuberculosis. The retinal lesion may be slightly decentralized, although this finding is rare. The prognosis is generally favorable, cases of secondary detachment being rare. Hypermetropia is one of the most common symptoms, disappearing with regression of the process. Treatment is directed toward the cause—tuberculin desensitization, removal of foci of infection, abstention from allergic substances and treatment of syphilis when present.

M. E. ALVARO

# Society Transactions

EDITED BY DR W L BENEDICT

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AMERICAN OPHTHALMOLOGICAL SOCIETY

Eugene M Blake, M D, *President*

Walter S Atkinson, M D, *Secretary-Treasurer*

*Eighty-First Annual Meeting, Hot Springs, Va, Nov 12-14, 1945*

## Early Ocular Manifestations in the Laurence-Moon-Biedl Syndrome DR DONALD J LYLE, Cincinnati

The Laurence-Moon-Biedl syndrome consists in obesity hypogonadism, mental retardation, polydactyly and retinal degeneration. The onset is in early life, and the disease may be detected before the school age. The subjective symptom is loss of central vision, not correctible with glasses. Three case reports were presented. Other conditions which resemble the Laurence-Moon-Biedl syndrome and which must be differentiated from it, are heredomacular degeneration, Leber's optic atrophy (hereditary optic nerve atrophy), cerebromacular degeneration and retinitis pigmentosa.

### DISCUSSION

DR WALTER I LILLIE, Philadelphia. Dr Lyle's differential diagnosis of the Laurence-Moon-Biedl syndrome is excellent. The early stages of this syndrome often place the ophthalmologist in a peculiar position. At this time the fundi are normal, but the central visual acuity is reduced and is not improved by corrective lenses. There is a central scotoma in the field of vision of each eye. Young persons with this syndrome have increased weight, and the condition is suggestive of a pituitary disorder. Because the ophthalmologic examination reveals a prechiasmal syndrome which might be of pituitary origin, roentgenograms of the sella turcica are necessary for proper diagnosis. As far as I know, however, the roentgenogram in cases of this syndrome reveals no pathologic changes in the region of the sella turcica. When the syndrome is well developed, there are definite pallor of the disk associated with loss of central visual acuity and typical findings of retinitis pigmentosa. There is then no difficulty in differentiating the condition from the ordinary chiasmal syndrome. The ophthalmologist should be alert to the probability of bilateral chronic retrobulbar neuritis as the early stage of the Laurence-Moon-Biedl syndrome.

## Dust-Borne Infection in Ophthalmic Operations DR M HAYWARD POST JR, St Louis

Infections may take place in ophthalmic surgical procedures through any of the following sources: (1) contamination residual in the conjunctiva, the glands of the lids, the lacrimal apparatus and the skin,

(2) the hands and gloves of the surgeon, assistant and nurses, (3) droplet infection through the masks of the participants, and (4) dust-borne organisms. A series of experiments designed to study the dust-borne infections indicated that dust-borne organisms play a large part in the contamination of water bath, towels and instruments. The predominating organism in all growth-yielding cultures was the *Bacillus subtilis*.

Although air conditioning either by sterile lamps or by triethylene glycol vapor is effective in reducing the number of air-borne organisms, it is quite impractical in most hospitals. The following simple procedures are of value in combating infections from dust-borne organisms.

1 Covers should be kept on all solutions, towels, instruments, and the like, as much as possible.

2 An aqueous solution of benzol konium chloride ("zephiran chloride"), or similar detergent, is substituted for the water bath.

3 All instruments that are actually to enter the eyeball are dipped in a suitable sterilizing solution, or boiling water, for at least two and one-half seconds immediately before use.

4 Some method for air sterilization in the operating room is installed as soon as practicable.

5 All blankets and sheets are treated with a dust-laying oil (Harwood, F. C., and others. *Brit M J* 1:615 [May 6] 1944).

6 The floor of the operating room is treated with some type of dust-allaying preparation.

#### DISCUSSION

DR WILLIAM M. JAMES, St. Louis. Since Dr. Post has been interested for many years in sterilization of the sharp instruments used in ophthalmic surgery, it is fitting that he should call attention to the dust-borne infections and, at the same time, suggest methods of their control. The results of cultures of material taken by Dr. Post and his assistants from surgical instruments indicate that the instruments were being contaminated in the uncovered water bath. When they dipped the instruments either in boiling water or in benzol konium chloride, 1:3,000, the percentage of culture-yielding growths was reduced considerably. Dr. Post has told me that some rusting of the instruments has followed the use of benzol konium "zephiran" chloride in the water bath. The Alba Company states that this factor may be controlled by using a 0.5 per cent solution of sodium nitrite in the solution of benzol konium chloride.

DR WILLIAM H. CRISP, Denver. Everything which one can do to improve the sterilization of instruments is not only justified but demanded. I wonder, however, whether one does not underestimate the capacity of nature. I have never seen anything to lead me to believe that I picked up an infection from the air of a well conducted operating room. Throughout most of my professional career, any sterilization of instruments has been done by simple immersion, not in actively boiling water but in water which has been boiling before I used it. For sterilization of my knife, I simply hold it for sixteen to twenty seconds



in the water under which the gas has just been turned off, so that the water is at boiling temperature but not actually boiling. Most killing or cooking processes are accomplished well below the boiling point. It is my opinion that most inflammatory processes which one sees after operations on the eye are due to some variation in surgical technic rather than to active infection, this I believe is especially true of the slow inflammatory processes. Any foreign material or any trauma will favor bacterial infection. I do not believe any ophthalmic surgeon ever performs two successive operations in exactly the same way. There are slight variations in technic. Some of these depend on slight variations in the anatomic structure of the individual eye, and I believe that the neatest possible surgical technic with avoidance of undue trauma to the tissues, plays a much more important part than extreme efforts to avoid infection. Many years ago, before sterilization was given as much thought as it is today, the older Pagenstecher always passed the cataract knife between his lips just before making the incision. He said that this actually made the knife go through more easily, and he probably had no greater proportion of cases of infection after his cataract operations than most present day surgeons. The point is that under favorable conditions the eye is extremely resistant to the threat of infection. One's main salvation lies in the simplest and most straightforward possible surgical technic, with proper respect to the exact anatomic structure of the patient's eye. I appreciate the fact, however, that Dr. Post has been doing some excellent scientific work, and I very much respect what he has done.

DR FRANCIS HEED ADLER, Philadelphia. I should like to call attention to a factor in dust-borne infections which will become of increasing importance in operating rooms, and that is air conditioning. In 1937 our new operating room was opened. My colleagues and I had no trouble from infections until the first hot week of the summer, when the air conditioning system was turned on. In that week I had 2 cases of intraocular infection. Cultures of material from one of the eyes showed colonies of *B. subtilis*, and the contamination was traced to the air in the room, which was heavily laden with the hay bacillus. It was discovered that the air which came through the system was passing through a chamber loaded with dust and hay bacilli. By spraying the duct through which the air is pumped with triethylene glycol our problem was solved, and since then we have had no further infections.

DR ARTHUR M. YUDKIN, New Haven, Conn. From 1939 to 1945, when it was most difficult to obtain well trained assistance in the operating room and the operating teams were overworked, my colleagues and I were free from postoperative infections. It was not unusual for an ophthalmic operation to follow an abdominal operation, yet with ordinary care no infection of ocular tissue was observed. It is a miracle that more infections are not encountered after operations on the eye, for the conjunctiva cannot be sterilized properly and it is extremely difficult to free the air of air-borne infection. We observe the same operating room technic as that employed by the general surgeon. The noncutting instruments, towels, gowns, basins, dropper bottles and table covering are autoclaved under pressure. The medicaments are sterilized by the drug department daily. The cutting instruments are placed in Post's

original sterilizing solution for five to ten minutes. Post's recommendation of a system of sterilizing lamps to free the air of infective organisms is commendable, and I believe that the operating room of the future will be air conditioned and constructed so that the air can be sterilized.

DR M HAYWARD POST JR, St Louis. The subject of electronic air filtration is exceedingly interesting, but I have not heard of its use in the operating room. I agree with Dr Crisp, and I realize the truth of his comments. My experiments have demonstrated that the eye has a tremendous capacity to fight infection. Although my associates and I had 77.77 per cent contamination at the close of operation, the hospital records in the past have shown relatively few infections, about 0.1 per cent, with approximately 600 intraocular operations performed annually. However, if we can reduce that percentage to zero, we are making a definite advance. I might also cite in this connection our experience when Colonel Smith demonstrated his intracapsular operation for us in 42 cataract extractions in one afternoon. During those operations he smoked no less than four cigars, there were various complications, but no infections. I attribute the lack of infection at the hands of the older operators to the fact that they were careful not to touch the tips of their instruments, and that they used fewer instruments. In reply to Dr Adler's comment, I would say that I have read merely an abstract of my paper. In the complete paper, air sterilization with triethylene glycol and ultraviolet radiation is discussed, and ways are suggested in which they may be used with safety. Much remains to be done on that subject before the entire answer is known.

**Corneal Section with Long Bevel and Conjunctival Flap for Cataract Extraction: Preliminary Report** DR WALTER S ATKINSON, Watertown, N Y.

This paper was published in full in a previous issue of the ARCHIVES (35:335 [April] 1946).

DISCUSSION

DR DERRICK T VAIL, Cincinnati. Although one does not have all the reasons for the complication of reopening of the wound after cataract extraction, one can be certain that when the wound reopens one of two things happens: either a hemorrhage into the anterior chamber occurs as the result of rupture of the newly formed blood vessels, or a prolapse of the iris takes place. I must confess, however, that I am not entirely satisfied. There is evidence in the literature, particularly in a recent article by E. E. Neff, pointing to the relatively low incidence of hyphema when a preliminary iridectomy is done. Perhaps the role of the freshly cut vessels of the iris is a greater one than is usually thought. On the other hand, hyphema is not less frequent after a simple extraction or after a small peripheral iridectomy.

What causes the wound to reopen and how to prevent it are still unsolved problems. It is obvious that pressure from the outside is the chief factor in its production. There is evidence that an overfilling of the anterior chamber takes place on the fourth or fifth day after operation, signifying relative glaucoma. I am particularly wary in the case in which the anterior chamber is deeper than normal during the first week.

after operation. A slight excess in the intraocular pressure during this critical period of healing or a trivial pressure applied to the eye from any source would be enough to rupture the fresh wound. Further careful studies and comparisons of the various types of corneal and corneoscleral-conjunctival incisions may give more information. It is known that there is more vascularization when the sclera, and particularly the conjunctiva, is involved in the incision. Although Dr. Atkinson's tables are significant and valuable, the series is too small to permit conclusions. One or two hemorrhages more or less would have altered his percentages impressively. When one considers, however, the serious complications that arise from delayed wound healing, leakage and collapse of the anterior chamber, one is impressed with the necessity for the use of corneoscleral sutures. It is hoped that Dr. Atkinson and others will persist in their precise studies and continue publication of their statistics.

DR. JOHN H. DUNNINGTON, New York. The technic now advocated by Dr. Atkinson is one that should receive serious consideration, for early restoration of the anterior chamber is the greatest preventive of future trouble. Use of the conjunctival covering for the entire incision is greatly to be desired and its value widely appreciated, as is the necessity of firm closure of the wound. Corneoscleral sutures are generally accepted safeguards, and most surgeons agree with the author that it is safer to place them prior to opening the eyeball. If intentional beveling of the incision lessens the frequency of a leaky wound, then by all means it should be used. In my opinion, further experience with a larger series of cases is necessary for the proper evaluation of this type of incision. I should like to ask the author whether he thinks that such a beveled incision increases the amount of astigmatism. Attention to minutiae combined with great operative skill is evidenced by the excellent results obtained in these series of cases, and I believe these factors are much more important than the beveling of the incision.

DR. BURTON CHANCE, Philadelphia. I suppose the method of cataract extraction will be a subject for discussion as long as humanity exists. I wish to refer to the method practiced by the late Dr. Edward Jackson. In the time that I was assistant at Wills Hospital, I had the opportunity of observing the methods of many operators. In my last weeks Dr. Jackson had a "cataract month," operating every day. He used a knife combining the features of the triangular Beer knife and of the Graefe knife with which he incised a rather wide bevel—only rarely with a conjunctival flap, and never with a suture. For those thirty-one days I had Dr. Jackson's patients under the closest observation, and his results were uniformly beyond what others obtained, on the average, the patients left the hospital at the end of one week. I suppose I had the opportunity of seeing every cataract method in vogue at that time, so I have spoken in praise of Dr. Jackson's beveled incision.

DR. HAROLD H. JOY, Syracuse, N. Y. The keratome section is a rational procedure in cataract surgery. It results in a more firmly closed wound than that produced by the Graefe incision, and an increase in length of bevel increases the firmness of closure. I agree that a tightly closed wound requires direct coaptation of its margins and that this is more often obtained with the McLean suture than with the Stallard suture. I should like to ask Dr. Atkinson for his impression as to the

relative importance of the type of section and of the type of suture in preventing the complications of leaking wounds and hemorrhage into the anterior chamber

Conceding that the incidence of filtration and hyphema is lessened by the use of the long bevel section, it is essential to know whether it is technically practicable. With this procedure, the wound is not so large as it seems and is complicated by the presence of the corneal shelf. As Dr. Atkinson stated, this ledge necessitates tumbling of the lens and offers potential difficulty in case of rupture of the capsule. I believe this point should be emphasized, for, while the incidence of unintentional rupture may not be large, it is important to consider any additional risk involved in cataract extraction. In the presence of a fairly wide ledge, jamming of the nucleus beneath it might be embarrassing, particularly if vitreous appeared. Also, it might interfere with an iridectomy and favor incarceration of the pillars of the iris. I have used Dr. Atkinson's technic in 24 cases. Thus far no serious postoperative complication has appeared. From my limited experience with Dr. Atkinson's technic, it is my impression that it is a feasible and safe procedure for the average ophthalmic surgeon.

DR. JAMES W. WHITE, New York. I observed several of Dr. Atkinson's patients last summer in Watertown. I saw 1 patient in his office who had been operated on some time before, with vision of 20/20 or better and a round pupil. She was a satisfied old lady with a beautiful result. I later went to the hospital with Dr. Atkinson and saw 7 patients in the ward, all but 1 of whom were sitting up, within the week after operation, and they all looked very nice, quiet and in no trouble whatever. I then went to the hospital operating room and saw Dr. Atkinson remove a cataract by the method just described. I cannot imagine anything going more smoothly. There were no complications, the lens was removed in capsule.

DR. ALAN C. WOODS, Baltimore. I am in full agreement with Dr. Atkinson's general observations. There are two points which I should like to emphasize. 1. With the McLean suture it is necessary to have the corneal section in the right place, otherwise, one will cut the sutures. 2. With the McLean suture one can get any degree of beveling desired simply by increasing the angle of the Lunsgaard knife with which one makes the primary incision at the limbus. It has been my experience that the large bevel in the center increases the difficulty of doing the iridotomy, and there is also the chance of the lens being caught on the edge of the bevel as it tumbles. I should like to ask Dr. Atkinson whether, in his figures on leaky wounds, he includes the frequent loss of the anterior chamber which occurs on removal of the suture. This is one of the definite drawbacks to use of the McLean suture, and in my experience it has a rather high incidence, probably 2 or 3 per cent of cases. It is usually a trivial thing, it corrects itself, and the chamber reforms in a day or so.

DR. LAWRENCE T. POST, St. Louis. Having been troubled considerably by late hemorrhage and having become convinced that it was chiefly due to the breaking of new-formed vessels in the incision from the fourth to the tenth day after operation, I changed my technic somewhat by dissecting down the corneal flap well onto the cornea, so that I could see a clear, avascular area of cornea of about 0.5 mm., or perhaps

even as much as 1 mm, at the limbus, and making the section through this area. Since adopting this procedure I have found the incidence of late hemorrhage to be gradually reduced.

DR WALTER S. ATKINSON, Watertown, N. Y. Since submitting this paper, I have done 46 more extractions by this method making a total of 96 for group 3 (cases in which a conjunctival flap was first made). The percentage of shallow chambers and small hemorrhages was essentially the same as that for the first 50 cases, so in the 96 cases of group 3 there were only 1 case of empty chamber and 1 case of hemorrhage large enough to prolong the patient's stay in the hospital. Some one called attention to the small percentage of cases in which vitreous presents. Unfortunately in the last 46 cases there was 1 case in which vitreous presented making a little over 1 per cent for the series. With regard to the astigmatism, the averages for the three groups do not vary greatly.

Dr. Joy has asked my impression of the relative importance of the section and of the type of suture in the prevention of leaky wounds and hyphema. Both seem to be of considerable importance but a long-beveled section in corneal tissue completely covered with a conjunctival flap impresses me as of more importance than the type of suture used. Introduction of the suture before the section is preferred, principally because it is safe. Furthermore it is desirable to have the interval between the section and the extraction as short as possible so that the pupil will not contract and make it necessary to do an iridectomy. The suture, however, may be introduced safely just after the keratome incision and before the wound is enlarged with scissors. In this manner secure closure with good approximation may be obtained.

In regard to Dr. Woods' comment, no iridotomy was done in the cases in which the corneal ledge covered the iris. In group 3 there was only 1 case in which the chamber was not reformed at the first dressing. Oftener the chamber became shallow later, about the fourth or the fifth day. Occasionally a shallow anterior chamber was observed after the suture was removed. In the cases of group 3 the suture was removed about the twelfth day. If the suture was tight, so that the point of the scissors could not easily be introduced under it, a small sharp Bard-Parker knife was used. In doing it this way, the knot is first pulled up a little with forceps so that the cutting edge can be drawn across the suture just back of the knot. The suture is not held with the forceps while it is being cut. All have learned how dangerous this is.

**Technical Uses of Air in Ophthalmology** DR WENDELL L. HUGHES, Hempstead, N. Y., and (by invitation) DR J. GORDON COLE, New York

This paper, with discussion, was published in full in a previous issue of the ARCHIVES (35: 525 [May] 1946).

**Relationship of Rubella in the Mother to Congenital Cataract in the Child** DR EVERETT L. GOAR and (by invitation) DR CHARLES R. POTTS, Houston, Texas

Seven cases of congenital cataract were presented, in all of which the anomaly was accompanied with other defects, usually a congenital

heart lesion poorly developed musculature or retarded mentality In 6 of these cases the cataract was bilateral, in 1, unilateral Six of the 7 mothers had rubella in the early months of pregnancy One whose baby had the syndrome gave no such history

The cataracts were typical in that the embryonic nucleus, which develops soon after the fibers are laid down, was affected

Five of the patients had both eyes operated on, with use of ether anesthesia The through and through discission advocated by Ziegler was done Fair results were obtained in all cases Secondary glaucoma did not occur

It is considered wise to operate on these infants within the first two or three months, before nystagmus begins

#### DISCUSSION

DR ALGERNON B REESE, New York Dr Goar and Dr Potts present a longer period of observation in these cases than I have encountered before They have observed that the cataract is characterized by a central, densely opaque disk, surrounded by a more or less transparent cortex It has been my experience that this central disk can, and should, be removed from within the confines of the capsule and allowed to rest in toto or fragmented in the anterior chamber at the time of the needling operation If the nucleus is extruded like a pea from a pod and rests in toto in the anterior chamber, it will absorb readily If the central disk is removed from the capsule, there is little additional soft lens matter for absorption, and a black pupil is achieved in a shorter time than is usually the case with other types of congenital cataract

I agree that the patients stand ether anesthesia well in spite of the heart lesion

It is possible that the offending disease in these cases is other than rubella which I am told by authorities is a pleomorphic disease, and a rather loose entity

Dr Frank Payne and I are studying cases of retrolental fibroplasia We have been impressed with the number of mothers of the patients who give a history of bleeding, fever or some other irregularity during pregnancy Children whose mothers are thought to have had a sub-clinical infection with the toxoplasma may have congenital anomalies These observations may implicate infection in early pregnancy as a most important factor in the malformation of the embryo, and thereby open a new vista in the field of congenital anomalies

DR FREDERICK C CORDES, San Francisco My colleagues and I have seen 10 cases in which rubella was contracted by the mother during the first three months of pregnancy and in which the infants had cataract formation, as well as other typical changes In this series were 2 cases of monocular cataract in which the retina of the noncataractous eye was good and vision was present, but ophthalmoscopic examination revealed fine particles of pigment clumped and scattered throughout the fundus, being most prominent in the foveal area The pigment was in the retina The disk was pale, but the arteries were not contracted Except for the vessels the picture suggested retinitis pigmentosa

Also of interest was the case of a girl of 9 years whose mother had rubella during the second month of pregnancy The mental age of the child was 2 years At birth she had weighed 4 pounds (1.814 Gm)

and was ill nourished and difficult to feed. Bilateral cataract was present at birth and operation was performed at the age of 3 years, with fair visual results. From this experience it appears that cases of this condition have been encountered in the past, but the etiologic factor had not been established, so that the defect was not recognized as an entity.

After therapeutic curettage, an 8 week embryo with a history of rubella during the sixth week of embryonic life was obtained. The lens of the eye shows definite retardation. This observation indicates that changes in the lens do occur at the time of the infection with rubella. It has been shown that the filtrable viruses may be found in the amniotic fluid. The absence of protection of the lids and of Descemet's and Bowman's membranes during the first three months of embryonic life may permit toxic agents in the amniotic fluid to act directly on the lens. The presence of these barriers after the third month may explain the absence of the changes in the lens when rubella is contracted during the latter part of pregnancy. The study of more specimens is necessary before these observations can be evaluated.

DR LAWRENCE T. POST, St. Louis. Dr. Goan has cited me as having advocated local anesthesia for operation on infants with this defect. Experience in 2 cases certainly does not permit one to do more than suggest. In my first case I performed the operation with the patient under ether anesthesia, the patient died the following day. Whether the anesthesia was in any way responsible I do not know, but, certainly, it was an added insult to a subnormal child. In the next case I used instillations of cocaine, as for a needling operation in an adult. The nucleus was easily tipped into the anterior chamber and sliced into sections, as described by Reese. This baby is still alive, one year later, and has clear, aphakic pupils but is mentally and physically retarded.

A second point to be considered is whether or not cataract followed rubella in mothers prior to the epidemic in Australia in 1941-1942. It is not unlikely that this particular epidemic of rubella, which later reached the United States, possibly from Australia, was one in which the peculiar sequelae of cataract, congenital heart lesions and disturbances of the central nervous system were important features, not often present in other epidemics. If the syndrome had occurred frequently before, it is more than probable that it would have been noted.

A practical question is whether abortion should be induced in mothers who have rubella in the first two months of pregnancy. I believe that this should not be advocated by the ophthalmologist, for the following reasons: (1) The diagnosis of rubella is not certain, (2) there have been cases in which normal children have been born in spite of the rubella, and this will continue to occur, (3) it is not rare that after an induced abortion there will be no subsequent pregnancy, (4) it is questionable whether there is good ethical background for inducing abortion in cases of this sort in which there is only the prospect that the mother may produce an abnormal child, (5) the ophthalmologist would be counseling the performance of a questionable procedure by some one else, that person of necessity having to take the major share of the blame if the outcome was not as successful as was hoped.

DR E. C. ELLETT, Memphis, Tenn. (discussion read by Dr. R. O. Rychener, Memphis). After the publication of Gregg's report, the

history of the occurrence of rubella in the mother in the early months of pregnancy was investigated in 10 cases of congenital cataract. In 4 of these cases there was a positive history, in 1 case, a history of measles, and in 1 case, a severe attack of influenza. In most cases the children were poorly developed, in 3 there was congenital heart disease, and in 1, clubfeet. In 1 case the patient was an adopted child for whom no history was obtainable. The anesthesia was without incident in all cases in which a general anesthetic was used, and the surgical aspects presented nothing different from those in similar cases.

DR JOHN GREEN, St. Louis. I saw a case of this type in consultation. The baby, though not premature, weighed only  $3\frac{1}{2}$  pounds (2,087 Gm.) at birth. The feature which interested me particularly was that this baby had delicate posterior synechias in one eye. There was no ciliary congestion, but, because of the presence of adhesions, I counseled a delay of several months before operation.

At operation my colleague encountered some difficulty on account of the extremely small size of the eye and planned to have a very small dissection knife made for use on the other eye.

DR T. L. TERRY, Boston. A brief summary of the changes in the eyes observed at autopsy in an infant who died at 4 months of age, the mother having had rubella late in the third month of pregnancy, should not detract from the formal report that is being prepared. The most striking changes were in the crystalline lens of each eye. These were seen only on careful microscopic study with subdued illumination. 1. The individual lens cells were preserved in the fetal nucleus. One could make out dimly the nuclei of these cells, although they appeared somewhat "ghostlike." No keratinizing process was present in the center of the lens nucleus of either eye. 2. Surrounding the nucleus were groups of rounded and irregular, basophilic globules, the arrangement and appearance of which were similar to those seen in lamellar cataracts of tetany. 3. The fetal nucleus in each eye was located far forward, with practically no cortical material between the nucleus and the anterior lens capsule. This abnormal position of the fetal nucleus appears to have resulted from the inability of the lens fibers, growing after the nuclear and perinuclear injury, to insinuate themselves in front of the fetal nucleus. The newly formed fibers tended to be arranged in irregular layers, and even concentric whorls. There were also some scattered mild cataractous changes in the cortex.

The fetal nucleus measured 1.5 mm. in diameter, which corresponds rather closely to the normal size of the entire lens at the latter part of the third month of embryonic life.

It may be characteristic in cases of maternal rubella for the lens nucleus to become changed in its position within the crystalline lens, as the microscopic sections seem to indicate. I have seen 2 other cases in which that did occur.

Why the cataract may be unilateral is another unexplained problem. In the retina of the noncataractous eye there were pigmentary changes minute in size and, as Dr. Cordes has said, similar in form and distribution to those of retinitis pigmentosa, although I do not intend to infer that this condition is related to retinitis pigmentosa.



This association shows that "maternal impression" really does exist but the condition results from a physical, rather than a psychologic, trauma. The damage begins at the time at which the embryo is most susceptible. The injury may be derived from the toxins, from the increased temperature or from infection with the virus itself.

It should be mentioned, also, that one can now indicate to the parents of infants who have rubella cataract that the ocular disturbance is not hereditary.

DR WENDALL L. HUGHES, Hempstead, N. Y. I should like to ask whether the authors have seen any cases of unilateral congenital cataract in the babies of mothers who have had a typical history of rubella at the proper time, that is, at the three month period of gestation.

DR C. A. CLAPP, Baltimore. I should like to ask the authors whether they interrogated the mothers as to the occurrence of other types of infection during the early months of pregnancy. I feel that possibly any type of infection or toxemia in the early months of gestation may cause lenticular changes.

Of the last 6 cases of complete congenital cataract which I have seen, and in which I have questioned the mothers carefully as to any illness during early pregnancy, I have found that there was no history of any indisposition in 5 but in the sixth scarlet fever occurred during the second month of pregnancy. In no case could I obtain a history of rubella.

DR ALAN C. WOODS, Baltimore. I think there is no question as to the establishment of this clinical entity. It brings up several interesting points, however, one of which Dr. Post has emphasized. I have had 3 pregnant patients sent me with the request that I sign a slip stating that a therapeutic abortion is justifiable on the grounds that these prospective mothers had rubella early in pregnancy. I was a little suspicious that these mothers might be using their history of rubella as a means of getting rid of unwanted progeny. What is known is that a number of mothers of babies with the syndrome of cataract, cardiac malformation and disturbance of the central nervous system give a history of rubella early in pregnancy. What is not known is the percentage of mothers who have had rubella who will produce this type of progeny. I think there is a grave question whether 100 per cent of such mothers will produce these defective children. The question is of such interest that Dr. Corner, head of the Carnegie Institute for Embryology, is contemplating a long range and extensive study on monkeys to determine the effect on the offspring of rubella early in pregnancy.

DR EVERETT L. GOAR, Houston, Texas. In reply to Dr. Post's comment, we are not advocating therapeutic abortion. I believe that if we could say positively that every mother who has rubella during the first few months of pregnancy would have a baby of this sort we would be justified in advocating therapeutic abortion, for these infants are the most miserable I have ever encountered. In the light of present knowledge, however, such a stand would put us in a disadvantageous position, because we cannot prove it.

I believe that the slides which Dr. Cordes and Dr. Terry have shown demonstrate that this cataract is not a truly inflammatory affair. This

picture coincides with the clinical appearance, because these children do not have the dense posterior synechias familiar in children who have cataract from intrauterine inflammation

Dr Clapp, we interrogated the mothers as to other forms of infection, and we could get no history of maternal infection except for rubella

In regard to the question of these cataracts being unilateral, in 1 of the 6 cases it was unilateral. Why that should be so when it is undoubtedly a constitutional condition is difficult to say

#### **The Vossius Ring** MAJOR TRYGVE GUNDERSEN, Medical Corps, Army of the United States

The author reports 19 cases of Vossius ring, all having occurred as a result of battle injury in young American soldiers. In every case intraocular hemorrhage was present. The size of the ring was practically constant, 2.25 to 2.75 mm. being the limits of variation in the diameter. It is concluded that the ring does not consist of this pigment left behind on the lens capsule as a result of the injury, but that the most tenable explanation for its formation is the deposition of blood pigments from the aqueous in characteristic fashion during the interchange of fluids through the anterior lens capsule

#### **Persistence and Hyperplasia of the Primary Vitreous** DR ALGERNON B REESE, New York, and (by invitation) DR FRANK PAYNE, New York

This is a report based on 50 cases of persistence of the primary vitreous. The authors feel that the lesion represents the congenital remains or persistence of embryonic tissue and, therefore, is not essentially an acquired one. Secondary complications may be hemorrhage, cataract, corneal changes, glaucoma and detachment of the retina. Hemangioma seems to be closely related to persistence of the primary vitreous, both conditions consisting of congenital remains of angioblastic mesoderm. Treatment is not altogether satisfactory

#### DISCUSSION

PROF IDA MANN, Oxford, England. These cases are all good examples of the general principle of the production of developmental anomalies through arrest at a definite stage of intrauterine or extrauterine life, followed by aberrant growth. This aberrant growth may lead to excess normal tissue or, by atypical differentiation of pluripotential cells, to the appearance of tissue abnormal in that situation, e. g., cartilage and unstriated muscle in the posterior vascular capsule. That prematurity is often a feature of these cases is not surprising, since the interference with development seen in the eye may be part of a general aberration, manifesting itself both as prematurity and in various associated malformations. The primary cause of the whole clinical picture is likely to be a maternal upset, probably nonspecific in nature but specific in time. That this can happen has been shown by many experimental embryologists and is now known to occur in man, e. g., in cataract due to rubella and in the maldeveloped retinas of fetuses roentgenographed in utero. I suggest to Dr Reese that it would be more helpful if he

would consider classifying his cases not on clinical findings alone but on the probable stage in development at which the initial arrest occurred. Judging the cases from a purely embryologic standpoint, I should say his type 1 begins earliest, probably at about the 15 mm stage, certainly before the end of the organogenetic period. His type 3 is also early, beginning certainly before the third month, and is allied to congenital retinal septum, which can also be explained as a localized linear failure of secondary vitreous. Type 2 probably begins between the fifth and the sixth month, as there seems to be an accompanying arrest of formation of the angle of the anterior chamber while the cases of type 1 in which glaucoma subsequently develops arise possibly only a little later. Type 4 is obviously related to an arrest at the very end of fetal life.

This classification could be checked and amplified if accurate data could be obtained of the time of the maternal upset, as evidenced by the occurrence of bleeding and of infections of the respiratory tract noted in 14 of the mothers. The cases would then probably be seen as a continuous series rather than as sharply differentiated types.

DR F H VERHOEFF, Boston. In specimens sent me for examination by the Army Medical Museum, I have seen all the conditions described by Dr Reese. I should like to ask him whether he has ever seen hemorrhage extending from the retiolental tissue into the lens, I have seen this in at least 1 case.

DR HENRY HADEN, Houston, Texas. I agree that the term persistence and hyperplasia of the primary vitreous is appropriate for the congenital abnormalities under discussion. The primary vitreous is composed of mesoderm which flows in between the rim of the optic cup and the lens, the mesoderm that accompanies the hyaloid artery as it passes through the fetal fissure into the optic cup and ectodermal fibers derived from the lens and the inner wall of the cup.

Toward the end of fetal life the mesodermal part of the vitreous disappears, and the permanent vitreous is exclusively ectodermal in origin. In certain circumstances, a portion of the mesodermal tissue is not absorbed, and a variety of lesions, such as Dr Reese and Dr Payne have described, are the result. The size, position and style of the lesion are influenced by the fetal age at which the normal recession of the primary vitreous ceased.

DR T L TERRY, Boston. That Dr Reese and Dr Payne hold certain views in disagreement with mine is encouraging. Their belief that the abnormal development occurs before birth is the most important difference. The evidence is based on 1 instance, in which the infant, weighing 3 pounds 5 ounces (1,500 Gm), was observed on the day of birth to have the disease process well developed. Warkany has proved that in the young born of rats in an extreme stage of vitamin A deficiency abnormal eyes develop early in gestation. I have confirmed his observations. Chief among these abnormalities is the growth of mesodermal tissue in the meshwork of the tunica vasculosa lentis, behind the lens. Although such extreme depletion of vitamin A is not likely in the human mother, it could cause such a sequence of events. It may account for the lesion on which Dr Reese and Dr Payne base their conclusion of intrauterine development of the process in their most dramatic case.

The process can, and does, develop during intrauterine life. It has been observed in full term infants at time of birth. Although this is probably a process identical with that seen in the premature infants, I do not yet have proof that the two are identical. I should expect the ocular defect to manifest itself at birth, or very soon thereafter, in premature infants nearing term, whereas in the infants weighing 3 pounds (1,360 Gm) or less it would not appear for weeks, or even months.

A routine study of the eyes of premature infants, followed from the day of birth to a time when all danger of development of retrolental fibroplasia has passed, has shown me that this disease process can, and does, become manifest in some premature infants after birth. Clifford and I have not been able to determine during their incubation in which premature infants retrolental fibroplasia will develop, but Clifford has shown that in about 12 per cent it will develop several weeks or months after birth.

According to Clifford, the only associated defect is a lack of mental development in some of the infants. I have observed angioma in 17 cases. I have not found any statistics showing the frequency of angioma in infants as a whole, although I am told that it is high.

A less important difference in our views is that of terminology. The disease, I believe, represents a growth of embryonic connective tissue in the meshwork of the closed tunica vasculosa lentis, which reopens before its lumen has become impervious. I say "reopen," for the vessels of the tunica vasculosa lentis system had previously been observed when the eyes of extremely premature infants were first examined and had become invisible when they stopped carrying blood. The abnormality is not a persistence of the vascular tunic in its embryonic and early fetal state in a region where no such solid tissue is ever encountered during normal development. Thus, I object to the word "persistence," which the authors suggest. I consider primary vitreous to be the total mass of mesodermal and ectodermal syncytium between the lens and the retina up to the 40 mm stage. That blood vessels are a part of it I do not agree, although blood vessels for a time pass through it and perhaps contribute to its early growth. When these vessels disappear, I do not visualize the primary vitreous changing over to secondary vitreous, rather, it persists throughout life as the less viscous material filling the so-called retrolental span and Cloquet's canal. With this view Prof. Ida Mann told me she was in agreement. If it is correct to consider the hyaloid artery and tunica vasculosa lentis as an integral part of the primary vitreous, then the name "hyperplasia of the primary vitreous" loses much of its objection to me. Primary vitreous reaches its full growth at the 40 mm stage. If the retrolental fibrous proliferation represents a hyperplasia of the primary vitreous, even though it does not permeate the vitreous of these small eyes, it represents a very great hyperplasia indeed.

Exception might be taken to the length of the name suggested by Reese and Payne. Of all the terms formerly used, "fibrovascular sheath" is probably the least objectionable, but it does not locate the disease process in any one organ of the body or in any position in the eye, as does "retrolental fibroplasia."

Because of the slow manner in which the lens material is absorbed after dissections, I have been eradicating the lens by a linear extraction associated with an iridectomy above and an iridotomy below, in an attempt to prevent blocking of the pupil. I have used this operation only when the anterior chamber is absent, lentocorneal synechias are present and central corneal opacities are developing. Careful suturing of the wound permits the retention of injected air in an attempt to prevent recurrence of the anterior synechias. After the operation an adequate anterior chamber is usually present.

**DR ALGERNON B REES**, New York. We stated that our classification was purely a clinical one and one adopted for convenience. Professor Mann's idea of making the classification include the stage at which the maldevelopment in the embryo occurs is well worth while.

**Dr Verhoeff** mentioned the relationship to hemangioma. I stated that our conception of a hemangioma is that it represents a congenital rest of angioblastic mesoderm which later begins to grow into a neoplasm. It does not behave like a true neoplasm clinically, because angiomas do not as a rule have the capacity for unlimited growth. We have never noted hemorrhage extend from the retrolental tissue into the lens, as **Dr Verhoeff** has.

We believe this lesion to be congenital irrespective of whether it occurs in premature or in full term infants. The matrix of the lesion is present at birth, with varying degrees of hyperplasia subsequently. This interpretation is not based solely on 1 case, as **Dr Terry** stated, but depends on several factors. 1 In premature infants the lesion was observed at birth in 1 case and at less than 1 week of age in another, in full term infants the lesion was noted at birth in 3 cases and at the age of less than 1 week in 4 cases. The clinical and pathologic features appear identical in the two groups. 2 The hyaloid artery, if absent at birth, never develops later, rather if it is observed it was necessarily present at birth. The hyaloid artery is always a congenital manifestation, and it is frequently associated with the condition under discussion. 3 The various tissues seen in these lesions originate from mesoderm, mesoderm does not form after birth.

**Dr Terry** disagrees somewhat with our conception of the primary vitreous. It seems to me our views in this regard are those generally advanced by embryologists. Irrespective of names, there certainly occurs in embryonic life an angioblastic mesoderm inside the eye, and normally this disappears. When it persists and becomes hyperplastic, we believe it gives rise to the various lesions described in this general group.

#### **Exposure and Fixation of the Eye in the Early Days of Cataract Extraction** **DR BURTON CHANCE**, Philadelphia

This paper was published in full in a previous issue of the ARCHIVES (36: 484 [Oct.] 1946).

#### **Ocular Imagery** **DR ALFRED COWAN**, Philadelphia

This paper was published in full in a previous issue of the ARCHIVES (35: 42 [Jan.] 1946).

## DISCUSSION

DR F H VERHOEFF, Boston Many years ago I published a paper entitled "Cause of a Special Form of Monocular Diplopia," in which I explained how monocular diplopia was produced by spherical aberration combined with astigmatism I pointed out that there were other phenomena due to monochromatic aberrations of the eye Such aberrations explain why a given amount of astigmatism does not always reduce visual acuity to the same extent An unusual amount of accommodation in senile eyes and of so-called accommodation in cases of aphakia are similarly explained There are many irregular aberrations to be considered, which may lead to serious errors in the determination of regular astigmatism

DR WALTER B LANCASTER, Boston Dr Cowan and I agree as to fundamental principles, yet we reach different conclusions

We are in agreement with respect to Gullstrand's statements It seems to me that Dr Cowan's quotation from Gullstrand and my position are fully in agreement The only possible grounds for charging a misunderstanding on my part is that I assume that Gullstrand meant what he said, possibly with slight exaggeration for emphasis, while Dr Cowan thinks Gullstrand did not really mean what he said However, Dr Cowan only makes clearer than ever that Gullstrand, dissatisfied with fictions and approximations, discarded the Gauss theorems as a guide to image formation and devised a more accurate and more useful approach

As a matter of fact, I make two reservations and go a little farther than Dr Cowan does Several years ago I stated that, in spite of Gullstrand's statement that the conoid of Sturm did not even approximate the path of the rays in an astigmatic eye, it was, in my opinion, only in so far as it did approximate that form that one is able to correct astigmatism One is dealing with approximations, and so formulas which are only approximate may be useful in aiding the understanding of what is often made an intricate problem In this reservation about the conoid of Sturm Dr Cowan and I are in substantial agreement.

The second reservation I should make is that the Gauss theorems cannot be cast aside, for they have immense historic interest and no ophthalmologist can be regarded as well educated who is not familiar with them in a general way Here, again, Dr Cowan and I are nearly in agreement

But experience has shown that the average good ophthalmologist does not use the Gauss equations in his daily work and has the crudest notions of image formation and the vaguest ideas about the significance of aberrations Therefore, I feel justified in saying that the subject of visual optics has not been well taught This is our first major difference a difference with respect to where the emphasis should be placed in teaching visual optics whether on the laws of refraction and the behavior of light waves or on image formation

We differ in other conclusions A closer examination reveals that the major part of the paper is devoted to the old controversy about refraction with drops I take issue with Dr Cowan when he states "A large pupil has little or no effect on the distinctness of the useful retinal image as long as the system is properly in focus whether normally by the accommodation or by the aid of a lens", or "In any subjective

examination a wide, inactive pupil is a distinct advantage," and when he says of Gullstrand's and other investigations of image formation, "The findings of all such investigations are very interesting academically," implying unimportance practically

Speaking of how the eye deals with the confusion circle, of which Gullstrand makes so much, Dr Cowan states that "since sharp vision is obtained only in the vicinity of the fovea, that part of the convergent pencil which best answers the purpose will be selected" The reason is that it gives the best image That part of the confusion circle which has to be disregarded is disposed of or suppressed, not because it falls on the periphery of the retina, but because with the illuminations ordinarily used much of that part of the blue circle is below the threshold of vision This is what Gullstrand has made so clear and convincing

Dr Cowan appears to be inconsistent or self contradictory in some of his statements Thus, he says that the aberration of any optic system increases with the diameter of the aperture, then he denies that this applies to the eye One of the chief functions of the pupil is to improve vision by excluding the extremely aberrant peripheral rays He then admits that the large pupil introduces difficulties in subjective refraction He says that "theoretically, no method of refraction, objective or subjective, is absolutely reliable with an active pupil" I retort that no method of refraction is reliable with a dilated pupil, either theoretically or practically

In the unmasking of latent hypermetropia, cycloplegia has a value This value is greatly exaggerated, (1) since actual spasm of the accommodation, for which it is especially recommended, is so rare that Hess, Hirschberg and others of enormous experience say that they have never seen a case, (2) since there are other ways which succeed in the majority of cases, (3) since cycloplegia as ordinarily practiced is incomplete and (4) since cycloplegia introduces other sources of error—the aberrations

My first teacher of refraction, Mauthner, of Vienna, stated emphatically that if a man could not measure the refraction without using "drops" he was not competent to practice refraction Nevertheless, I adopted the use of cycloplegia myself and have always advised beginners to use it After several years, I found I could dispense with "drops" in some cases Thus, my personal experience (not an isolated one) proved to me that the simple theory on which cycloplegic refraction is based has serious flaws Just as an understanding of the conoid of Sturm has proved invaluable in the measurement of the astigmatism, so an understanding of the caustic and its importance in selecting the focus for best vision is invaluable in measuring hypermetropia and for the final choice of correcting lenses In emphasizing, as I do, the advantages of measuring the refractive errors of the eye without cycloplegia, no one should assume that that method is the only one I ever use or recommend

I was surprised at something Commander Young told me about his experience in the Navy He had to train experienced optometrists and girls who had had no training whatever A knowledge of theory was not necessary for these persons to make refractions, therefore it seems to me that my fundamental thesis has not been refuted, namely, that the present method of teaching physical optics and refraction is not satisfactory

DR W H CRISP, Denver It is advisable for the practical refractionist to know that the eye is an imperfect optical instrument. The limitations of ocular optics constitute the most important reason for the incomplete reliability of retinoscopy as a final basis for prescribing glasses. But the practical refractionist does not need to delve very deeply into these mysteries.

In some discussions as to the size of the pupil it is assumed that the eye always uses the entire pupillary area. This cannot be the case, for the overlapping images produced by different parts of the pupillary area would otherwise often create confusion in the image impressed on the brain. There is excellent ground for assuming that nature usually selects a limited area of the pupil for purposes of definition and in some mysterious and wonderful way ignores the overlapping images produced by other parts of the same pupil.

In retinoscopy it is important to realize that as soon as glass lenses are placed before the patient's eye it becomes impossible for the examiner to look exactly at right angles to such lenses because of the light reflections, and that oblique observation at once introduces elements of spherical and astigmatic error.

DR ALFRED COWAN, Philadelphia Dr Lancaster kindly said that we agree on fundamental principles and yet reach different conclusions, but I think we do not agree even on fundamental principles.

To answer the many points he disputes I should have to repeat nearly every statement made. I feel I have not said one thing that is not based on the scientific facts, even with regard to determination of the refraction of the eye with an active pupil. I do not agree with Dr Lancaster's explanation of the suppression or disposal of the confusion circle, but, even if it were correct, the important fact remains that in the eye the aberration is disregarded.

I am surprised at Dr Lancaster's relating what Commander Young told him about teaching optometrists and girls to do refractions in the Navy. I have seen some of the results of this work.

**Paralysis of Ocular Elevation With and Without Ptosis** DR DANIEL B KIRBY, New York

This paper was published in full in a previous issue of the ARCHIVES (35: 199 [March] 1946)

#### DISCUSSION

DR JAMES W WHITE, New York In examining patients with this disturbance, it is not the paretic eye alone that should be studied. A paralysis of the same muscle or muscles will produce different effects, depending on the fixating eye. In the case of paralysis of the left inferior oblique muscle reported by Dr Kirby, if the right eye is the fixating eye, the left eye is in a position of hypotropia, but if the left eye is chosen to fixate, the superior rectus muscle of the right eye develops a pronounced secondary deviation. If the superior rectus and inferior oblique muscles of the left eye are paretic, there will be a field of binocular single vision below. As the gaze is directed upward, if the nonparetic eye fixates, the left eye is hypotropic but if the paretic left eye fixates, the right superior rectus has a secondary deviation in



eyes up and right and the right inferior oblique has a secondary deviation in eyes up and left. These variations are best studied with the screen test and followed with the screen comitance test, with the eyes not only in the primary position but in the different directions of gaze. The fixating eye in the primary position may be one thing, and one can never tell how this may change as the eyes are rotated from one position to another and fixation changes in the different fields.

The Wheeler operation will correct large amounts of hypertropia, depending on the fixating eye. I have tried both the splicing and the tucking operation at the insertion, and neither has given me as large an amount of correction as the Wheeler technic. Dr Kirby, after he had resected the superior rectus of one eye and advanced the inferior oblique of the same eye, thought he could duplicate the result in the fellow eye, and he did duplicate it absolutely. In the primary position the deviation varied from a trace of exophoria to a trace of esophoria, and there was no hyperphoria. There was a normal near point of convergence, and the nystagmus was definitely reduced.

DR CONRAD BERLINS, New York. Because of the seriousness of the prognosis in some of these cases, particularly in cases of young women, I wish to speak of 2 patients.

One young woman had complete paralysis of the right third nerve and had had a previous operation for ptosis which was only partly successful, her appearance was most unhappy because of the eyelid and the position of the eye. She was insistent that something be done, so I performed a resection of the superior rectus and transplanted the superior oblique muscle. I was successful in bringing the eye into fairly good position and in getting a small field of binocular fixation which she had not had previously. I subsequently raised the lid by the Reese operation for ptosis. I probably had beginner's luck, for I have not been so fortunate in subsequent transplantations of the superior oblique muscle.

Another young woman had bilateral ptosis, the result of congenital paralysis of the levator muscle of the eyelids and the elevator muscles of both eyes. The family was anxious to try something in spite of the danger to the cornea, as the patient's situation was rather desperate, a bilateral Reese operation was performed. She had only slight corneal irritation on two occasions, but by keeping the conjunctiva anointed at night with liquid petrolatum she has got along very well, is married and has two fine children.

In seeing these patients, the ophthalmologist should consider what it means to a young woman and should sometimes take a risk and operate even when it seems as though he might not be successful.

DR ALEXANDER E MACDONALD, Toronto, Canada. I have a case of ptosis, there is little tarsus left, and I propose to insert a diathermy needle at the fold of the upper lid and pass it up to the margin of the orbit on two or three occasions, so as to control any overcorrection. I should like to ask whether any member of the Society has done this and, if so, what the results were.

DR DANIEL KIRBY, New York. I have been discouraged by the very appearance of patients with third nerve paralysis and have not been

attempting to operate on them. Certainly, Dr. Berens is to be congratulated on his satisfactory result.

I am opposed to the production of any deep cicatrix or sclerosing of tissues, or to anything that will produce lagophthalmos. I think that diathermy might produce some lagophthalmos in the case described by Dr. MacDonald, and there may be a distortion of the upper lid, particularly because of the small amount of tarsus remaining.

**A Comparative Study of Sutures Employed in Operations on the Extraocular Muscles** DR CONRAD BERENS, New York, and (by invitation) DR HUNTER H. ROMAINE, New York

This comparative study of sutures employed in operations on the extraocular muscles includes a discussion of technical factors, i. e., ease of handling, adsorption and absorption, tensile strength and friction coefficient. The surgical procedures employed in these experiments on the extraocular muscles were limited to recession with scleral fixation and resections. The authors drew the following conclusions:

- 1 Cotton and silk sutures are most easily handled, the braided type being preferred to the twisted. Nylon (000000) is difficult to handle.
- 2 Nylon (000000) produced the least tissue reaction and had the greatest tensile strength.
- 3 The absorbable sutures have the advantage of not having to be removed. Plain surgical gut produces less reaction than chromic surgical gut.
- 4 In the presence of infection, nylon, cotton and silk sutures are preferable to surgical gut.
- 5 Plain surgical gut sutures (000) are sufficiently strong to attach any extraocular muscle under ideal conditions.

DISCUSSION

DR PHILIP MERIWETHER LEWIS, Memphis, Tenn. After having seen Dr. Romaine use nylon sutures in operations for squint, I have used double-armed 000000 nylon sutures in 20 resections and in 29 recessions. The conjunctiva in adults was closed with black silk and in young children with plain surgical gut.

A notable reduction in the amount of postoperative reaction was noticed in practically every case. I should like to ask Dr. Berens and Dr. Romaine whether, in their research on animals and on patients, they found that nylon sutures remained unencapsulated.

My only objection to the use of nylon sutures in operations for squint is that the needles are easy to bend. This bending may be avoided by grasping the needle nearer the point than is done with ordinary curved needles. A definite advantage is the ease with which the nylon sutures may be passed through the superficial fibers of the sclera in recessions.

DR LAWRENCE T. POST, St. Louis. I want to ask Dr. Berens whether with nylon sutures he has had any difficulty with slipping of the knots. There is a considerable difference in tendency to slip between twisted and braided silk sutures, the braided silk having a higher coefficient of friction and not slipping so much. It is advisable to make a double knot in the first tie when using twisted silk. I came to the

same conclusion as did Dr Berens about chromic and plain surgical gut. Having used chromic gut for a long while, I changed entirely to plain surgical gut because of the reaction.

DR AVERY D. PRANGEN, Rochester, Minn. In the evaluation of sutures used in operations on the extraocular muscles, the questions involved are (1) the use of plain versus chemically treated absorbable sutures, (2) the use of absorbable versus nonabsorbable sutures, (3) the use of fine versus coarse sutures, and (4) the absorbability of sutures, which the authors have considered.

Until ten years ago I used various types and sizes of silk sutures, even twisted and waxed sutures and reinforcing gold plates, but I was far from satisfied. Reactions were too common and too severe. At times sloughing and slipping of sutures occurred. Finally, the sutures had to be removed, a procedure often more difficult and painful than the original operation. At the suggestion of the late Dr P. C. Jameson, I turned to surgical gut sutures, which eliminated these objections. I am still using fine 000 to 0000 plain surgical gut sutures.

I have had no experience with nylon sutures. I prefer to use the absorbable sutures, which do not have to be removed.

It seems that tensile strength and size of surgical gut sutures are not related to their holding power. Also, I find that plain surgical gut sutures hold as well as chemically treated surgical gut sutures, and the plain sutures cause much less reaction. It has been my experience that plain surgical gut sutures do not slip. Fortunately, infection has played a minor part in my cases for the past twenty-eight years. I have lost only 1 eye, from a low grade endophthalmitis.

From the authors' report it would seem that either small plain surgical gut or nylon sutures are preferable. I prefer plain surgical gut sutures of small caliber because they do not have to be removed. With all knots tied outside the conjunctiva, a minimal amount of suture is left buried to cause reaction. It could well be that fine nylon sutures would be preferable in selected cases.

DR EDMUND B. SPAETH, Philadelphia. There are two observations of Dr Berens and Dr Romaine which confirm long clinical experience. The first is the unsatisfactory tissue reaction to the use of chromic surgical gut in operations on the extraocular muscles. It seems that use of this suture should be discontinued for any such operations. The principal complications are (1) reaction of the muscle and conjunctival tissue about the sutures, (2) delay in absorption of the knots and scleral sloughs and (3) unwanted scleral reactions.

The second point of interest is the matter of tensile strength and, with it, the size of the suture. It is known clinically that braided silk sutures are much easier to handle mechanically than are the twisted silk sutures, but the braided suture is not necessary from the standpoint of its greater tensile strength. Plain surgical gut has certain disadvantages, but it has adequate tensile strength for any demands made on it in muscle surgery. If the twisted silk suture can be lightly impregnated with a bone wax or a paraffin preparation, it has adequate tensile strength for any use or demand, can be of small caliber and has none of the disadvantages common to plain surgical gut. Clinically, it is almost ideal for all situations in which use of nonabsorbable sutures is permissible.

DR CONRAD BERENS Dr Lewis has asked whether we observe encapsulation of the nylon sutures. Yes, we find encapsulation of all the nonabsorbable types of sutures and of similar synthetic resinous material when transplanted into the orbit after enucleation, not only in the human being but also in animals.

The needle does bend easily. However, this property of the needle has an advantage in operations on the inferior oblique muscle. The needle is so easy to bend that it can be bent in any desired arc. Davis and Geck are making a special needle for this work, which will be affixed to blue nylon.

Dr Post has brought up an important point about the slipping of the knots, as I said, I recently had a case in which the nylon suture had slipped. Slipping of the knot occurred in spite of its being necessary to place two turns in the nylon and then make another knot, and another knot on that. In recent operations I have made a surgeon's knot, passing the ends of the suture backward through the muscle before cutting it. Our experience is the same as Dr Post's with regard to the braided suture—it slips much less readily, however, in transplanting Tenon's capsule we have found the braided silk suture difficult to use because of the increased coefficient of friction.

**Physiologic Factors in Differential Diagnosis of Paralysis of Superior Rectus and Superior Oblique Muscles** DR FRANCIS DEED ADLER, Philadelphia

This article was published in full in a previous issue of the ARCHIVES (36: 661 [Dec.] 1946)

DISCUSSION

DR W B LANCASTER, Boston Duane explained what he called overaction of the inferior oblique muscle as due to paresis of the superior rectus muscle of the opposite eye—an ingenious theory, but not in accordance with the physiologic facts and principles. Bielschowsky explained the observed behavior of the inferior oblique as due to secondary contraction of the antagonist following paresis of the superior oblique of the same eye, a theory which fits the well established pathologic physiology, for example, in cases of palsy of a horizontally acting muscle. Chavasse, accepting the contracture of the inferior oblique muscle as a natural consequence of paresis of the superior oblique, explained the behavior of the superior rectus of the opposite eye as an inhibitory paralysis, due to nonaction of the elevator muscle when the paretic eye is the fixing eye.

Habitual limitation of the movement of a sound eye in the direction in which the palsied eye habitually fixes may result in inhibitional palsy of the sound eye. Not being called on to elevate the eye, it appears to lose the ability to do so, and when elevation is demanded by covering the fixing palsied eye and urging the patient to look up in that direction the eye lags. If the sound eye is the habitually fixing eye, this functional inhibitional palsy does not develop. If the palsied eye is occluded so that the sound eye is made to fixate, it rapidly recovers its ability to look up, thus showing that the paralysis was of a functional inhibitional type.

It is true also, that in cases of ptosis, in which elevation of the eyeball is never called for, the eyes seem to lose the ability to look up, and one is led to believe that the superior rectus muscles are palsied, as well as the levator muscles of the eyelids. Upward movement of the eyeball has been inhibited so long that the muscles seem paralyzed, but the paralysis is of a functional inhibitional type. It would seem that a Mott's operation would be doomed to failure, but I have seen good results in such cases, as others here probably have. I have also seen the upward movement of the eyeball recovered when the ptosis was cured by one of the simpler operations such as tarsal resection. Orthopedic surgeons recognize inhibitional palsy as one of nature's methods of meeting a special situation.

Duane did not recognize the possibility of inhibitional paralysis, and Dr. Adler has made it clear that this is the true explanation.

DR WARREN S. RLISE, Philadelphia. A simple, but important, ocular sign that illustrates Dr. Adler's statement of the predominant effect of the oblique muscles is seen in cases of palsy of the third nerve and occasionally, of incomplete external ophthalmoplegia. It consists in torsion of the affected eye: the upper end of the vertical meridian turning inward as the eye attempts to move from above downward. This of course indicates preservation of action of the superior oblique and conforms to the physiologic dictate that the superior oblique acts as an intorter when the eye is abducted. In addition to its diagnostic importance, this sign presents an excellent medium of showing to the student the so-called secondary action of a muscle.

#### **Proliferation of Retinal Vessels Associated with Diabetes** DR ARTHUR J. BIDELL, Albany, N. Y.

The author discussed and presented photographs of the classic so-called diabetic fundus with recurring hemorrhages, proliferation of retinal vessels and formation of vascular membranes.

#### **Cultivation of Human Tumor in the Anterior Chamber of the Guinea Pig Eye** DR EUGENE M. BLAKE, New Haven, Conn.

Dr. H. S. N. Greene, of Yale University, has successfully transplanted various mammalian and human tumors into the anterior chamber of laboratory animals. No immediate reaction follows such transplantation, and it is probable that the tumor stroma dies and degenerates. The parenchymal cells, however, continue to live, obtaining nourishment from the surrounding mediums. When the delayed mild reaction in the iris occurs, the implant consists of essential cancer cells only, which have no species identity.

The author traced the development of human fibrosarcoma transplanted into the anterior chamber of a guinea pig eye. Attention was invited to the possibilities for further research in this field.

#### **DISCUSSION**

DR LAWRENCE T. POST, St. Louis. Incidental to work with the thermophile on which my candidate's thesis of 1924 (Thermophile Therapy and Experimental Studies, *Tr. Am. Acad. Ophth.* 22: 353-374, 1924) was based, I transferred the so-called Jensen sarcoma into the

anterior chambers of white rats and treated it with the thermophore at 160 C for one and two minute applications to the cornea. In about 30 per cent of cases the tumor continued to grow, and in most of these cases, if the tumor had not extended too far, the thermophore destroyed the growth. The principle has had practically no therapeutic application, except in a case of Dr William Luedde's, that of a patient with only one eye, in which many ophthalmologists who saw the patient concurred in the diagnosis of melanotic sarcoma of the anterior segment of the choroid. Since the patient would not consent to removal of the eye, Dr Luedde used the thermophore and followed the patient for many years thereafter. The last I heard about it the patient still had the eye and the growth had regressed. Further studies with human tissue should be made and different types of therapy tried. However, I do not by any means advocate the use of the thermophore in treatment of intraocular tumors.

DR BERNARD SAMUELS, New York. I agree with Dr Blake's theory that those elements in an implanted tumor which represent normal tissue disappear, so that only malignant cells are left to propagate. The slowness with which he observed the infiltrating type grow in the iris was probably due largely to the mechanical resistance offered by the normal stroma to the advance of the proliferating tumor cells. In man, slow growth is characteristic of the infiltrating type of primary malignant melanoma anywhere in the uveal tract. Dr Blake noted that the pedunculated implants grew rapidly. This was due to the fact that the tumor cells were disposed in a fluid medium, in which the resistance was not so great as in the iris stroma, furthermore, the resistance being equal in all directions, the mass assumed a globular form.

There are but two primary intraocular tumors of great importance—the malignant melanoma and the retinoblastoma.

DR EUGENE M. BLAKE, New Haven, Conn. It may be that the anterior chamber can be used to determine the malignancy of a growth. For instance, in a case of sarcoma of the soft palate of a Negro, in which portions of the tumor were implanted in the eyes of guinea pigs, the implants died in every instance, but when, within a few months, metastases occurred in the neck and portions of these were implanted in the anterior chamber, they grew in 100 per cent of cases. It might be possible to divide these tumors into two stages—the stage of dependency when they are dependent on their host for growth, and the stage of autonomy. When they reach the stage of autonomy, they will grow in the anterior chamber of a foreign host, but apparently they will not do so in the stage of dependency.

#### **Marginal Myotomy: An Analysis of Twenty-Two Cases** DR GLEN GREGORY GIBSON, Philadelphia

This article was published in the February 1947 issue of the ARCHIVES, page 175

#### DISCUSSION

DR ARTHUR J. BEDELL, Albany, N. Y. When I was an intern at Wills Hospital, forty years ago, Dr S. Lewis Ziegler taught me this operation. After leaving the hospital, I did marginal myotomy for only

a short time and discarded it for the reasons which Dr Gibson has so well stated

### Penicillin in Treatment of Gonococcic Conjunctivitis DR PHILIP MERIWETHER LEWIS, Memphis, Tenn

Over a period of eight and one-third years, 203 patients with gonococcic conjunctivitis were treated at the Isolation Hospital in Memphis. Of these, 123 were treated with sulfonamide compounds, 30 with penicillin and 6 with penicillin and sulfadiazine. In the series treated with penicillin there were no failures, no recurrences and no unfavorable reactions. The penicillin was administered topically, as well as systemically. Dr Lewis concluded that penicillin is at present the most effective and the most satisfactory agent for the cure of gonococcic infection of the eye.

### Plastic Eye Implant DR A D RUEDLMANN, Cleveland

This author described a new acrylic full eye implant and the technic of implantation. A firm and more nearly permanent attachment is obtained with the use of intermediate muscle plates of tantalum, the plates to be attached to the muscles and then to the plastic globe with tantalum wire. By the use of these plates the eye is retained in the socket. Anesthesia induced with sodium pentothal or solution of tribromoethanol U S P is easier than local anesthesia for the patient.

The implants may be varied in size and shape and can be made available for any type of restoration. Little attachment tissue is necessary, and the ocular conjunctiva is not essential to the implant.

Postoperative infection did not occur in any of the author's 50 cases. There was no postorbital granulation tissue and little tissue reaction.

Dr Ruedemann concluded that the implantation of a plastic eye is time consuming, painstaking and difficult but that the end results in the appearance of the patient and in the psychologic response justify the effort.

### DISCUSSION

DR ALAN C WOODS, Baltimore. It seems to me that the papers on ocular surgery presented to us fall into two general groups: (1) a large group, which deal with modifications of technic of operations already accepted, and (2) a small group, in which original new procedures are introduced. Dr Ruedemann's new operation falls into the group of original contributions.

While in Cleveland, I saw a number of patients who had worn these implants for periods of from two days to almost two years. I examined the implants carefully to see whether there was any fading of color or deterioration; I could discover none. I found that the patients, with one accord, were entirely satisfied and were vastly happier than the patient who wears an ordinary prosthesis. I went out to Cleveland somewhat of a doubting Thomas, but I came back converted. After I returned to Baltimore, I made several of these implantations, and other members of the staff followed me and did a number more. The results in the main have been all that Dr Ruedemann has described. In fact, I believe that when this operation is perfected and the technic finally stabilized the old method of enucleation will become obsolete.

In this operation I should recommend the cautious attitude. Accept it, but realize that there are certain technical difficulties which are not yet fully solved but which, I think, in all probability will be solved. Primarily, tantalum wire is difficult to handle. It has a tendency to kink or break when one is tying knots, and one has to begin again. Assistants must be trained to keep the wire rolling on itself, to catch every suture as the surgeon brings it through and to watch the wire carefully to keep it from kinking. That requires a little practice but can readily be done.

The method of handling the conjunctiva amazed me. Dr. Ruedemann told me that at first he had tucked it in and reenforced it, but finally he just left it, with a lateral suture on each side. I followed this advice and have had no infections or trouble from this source.

There is a great deal left to be desired in the manufacture of these acrylic eyes. Some of the implants we have received have been excellent fits, others have not been so satisfactory. The present method is to measure the eye in the orbit with an ordinary exophthalmometer, take the diameter of the cornea, make a color sketch of the iris and send that information to the American Optical Company. This procedure can probably be improved on.

I have had one complication in a few cases—the first implant was off axis, with a resultant squint. This required a subsequent operation for correction.

This operation is especially adapted for the correction of obliterated sockets. Instead of the old method of using a dental wax implant with a Thiersen graft, one can get almost complete restoration, with a beautiful result, in one operation by shaping up the orbit and implanting an acrylic eye.

DR LESLIE C. DREWS, St. Louis. I should like to ask Dr. Ruedemann whether he has thought of using a number of spikes on these plates, instead of the tantalum wire. He could simply push the spikes through the tendon and bend over the spikes.

DR A. D. RUEDEMANN, Cleveland. I can assure you that the process is not complete, and many improvements will be made. Dr. Woods has already made one.

The problem that Dr. Drews raised has just been studied by Dr. Woods's group; they put a clip on the end of the muscle, so that they do not have to sew it on.

#### A Device for Group Demonstration of Tests for Astigmatism. DR WILLIAM H. CRISP, Denver.

For the demonstration of tests for astigmatism the author devised a small apparatus to be set up beyond the objective lens of a 35 mm. film projector. The apparatus consists of a carrier, in which may be inserted a simple cylinder at a selected axis, and another cylinder which perfectly, or in varying degrees of imperfection, corrects the astigmatism created by the first cylinder. In front of these cylinders is a fixed metal arm on which can be supported a cross cylinder capable of the same manipulations as are those employed in testing a patient's eyes.



## DISCUSSION

DR JOHN GREEN, St Louis Dr Crisp states that "many refractionists have a relatively feeble notion of what goes on in a patient's brain during tests for astigmatism" I am convinced too, that ignorance of what goes on in the patient's eye during manipulations with the cross cylinder is fairly widespread, despite the clarification of the subject by both Jackson and Crisp

I am not entirely in agreement with the author's statement that "the nature of the tests with astigmatic dials is easier to apprehend than that of tests with the cross cylinder" This view may be valid when dealing with keen and highly intelligent patients, but with a not too bright patient I have to devote considerable time in attempting to get consistent answers to the query "Which are the most distinct lines on the chart?"

No one can deny the beauty of Dr Crisp's device for group instruction Might it not also be used as a preliminary exercise for patients about to undergo the tests?

I hope Dr Crisp may develop his device to illustrate pictorially the vagaries and aberrations of the accommodations

DR WALTER B LANCASTER Boston I wish to call attention to the fact that most of the methods used are qualitative, and not quantitative The aberration produced on the letters in the test by a 0.25 D cylinder is not quantitatively comparable to that produced in the human eye

In my paper read before the Academy in 1915 I discussed photographing the test objects with a camera made astigmatic, and I should like to show the results

In the figure  $p$  is the pupil or aperture,  $r$ , the retina the focus of the emmetropic eye,  $f$ , the focus when a  $-0.25$  D cylinder is added, and  $d$ , the diffusion circle (line if the cylinder is used) on the retina The magnitude of the blur depends on three factors (1) the size of the pupil, (2) the ratio  $df/pf$  and (3) the magnification of the image by the lens system

The distance, in millimeters of the focus behind the retina when the eye is made hypermetropic by a minus lens is indicated by  $df$ , in this case a  $-0.25$  D cylinder This distance is calculated as follows The focal length of the eye when the focus is on the retina may be taken as 22 mm, equivalent to 45.45 D, when the 0.25 D cylinder is added, the focal length becomes 22.12 mm, or 45.20 D, the new focus therefore, is  $-0.12$  mm back of the retina, and  $df = 0.12$  mm The ratio of  $df/pf$  is  $0.12/22.12$  or  $1/184$

In the case of the camera the focal length is 166.7 mm if a 6 D lens system is used When a  $-0.25$  D cyl is added, this becomes 5.75 D, or 173.9 mm The value of  $df$  is  $173.9 - 166.7$  or 7.2, the ratio  $df/pf$  is  $7.2/173.9$ , or  $1/24$

Thus, the blur in the eye is  $1/184$  of the pupillary diameter, 4 mm, which equals 0.021 mm The blur in the camera is  $1/24$  of the aperture, if the aperture is 20 mm, the blur equals 0.833 mm The blur circle (line) is forty times as large in the camera as in the eye, apertures of 20 mm being taken for the camera and 4 mm for the eye How much should one allow for magnification of image? The image size for an object at a given distance depends solely on the distance from the nodal point to the retina or film In the eye it is 17 mm from nodal point to

retina, in the camera it is 167 mm from nodal point to film. Thus, the camera image is ten times as large as the eye image. If one wishes the camera to have a blur circle (or line) comparable to the eye, the blur in the former must be reduced ten times that of the eye instead of forty times. This is readily accomplished by reducing the aperture to one-fourth its former size of 20 mm. With an aperture of 5 mm, the camera with a 6 D lens system would give images the blur of which would be comparable quantitatively to the blur in an eye with a  $-0.25$  D cylinder. By a similar calculation, quantitative results could be obtained with a camera with a lens of a different focal length. The same is true of a lantern.

Why not make such a demonstration to an audience or class, so that they may get a correct idea of what a  $0.25$  D lens produces in the way of blur?

DR F. H. VERHOEFF, Boston. Dr Crisp's apparatus is useful for instructing a group of students who know little about refraction. It would be a difficult matter to construct an apparatus that would simulate the optical defects of the normal human eye. I have never thought it worth while to attempt to do so, for each individual student has an optical apparatus of his own, his eye, which may be used for teaching purposes. If its refraction is normal one can make it abnormal as desired by means of spheres and cylinders.

DR W. H. CRISP, Denver. The point that Dr Lancaster emphasized as to the relatively large aperture in the human eye is an important one.

I have a supplemental note with regard to the apparatus. With a high class anastigmatic lens the effect may show less satisfactorily than with a cheaper outfit. The effect on the projection of certain astigmatic dials is at times almost as paradoxical as that of astigmatic dials on some patients. Used with the letters, however, the apparatus demonstrates some of the difficulties which patients experience in answering questions. Some letters, on account of their shape, are so distorted as to suggest a somewhat different judgment on the part of the patient than other letters, generally speaking, it does not pay to ask the patient to concentrate on a single letter, it is better to have him base his judgment on the survey of a whole line of letters as distorted by the cross cylinder in its two positions. The demonstration also illustrates the fact that the patient can sometimes make a more definite decision if he is looking at the larger letters, instead of at the smallest letters he is able to read. One also realizes the need for instantaneous reversal of the cross cylinder, without an interval in which the patient can be distracted by the more normal intervening appearance of the letters.

**Exophthalmos Caused by Eosinophilic Granuloma of Bone** DR MAYNARD WHEELER, New York

An abstract of this paper was published in a previous issue of the ARCHIVES (35:61 [Jan] 1946).

#### DISCUSSION

MRS HELENOR CAMPBELL WILDER, Washington, D. C. In the Orthopedic Registry at the Army Institute of Pathology there are 44

cases of eosinophilic granuloma of bone. Lesions of the skull were present in 20 cases, and in 5 of these there was a history of ocular disturbance. As far as I know, no definite correlation has been made between the ocular findings and the lesions in the skull.

### Indications and Contraindications for Keratoplasty and Keratectomy.

DR RAMÓN CASTROVIEJO, New York

Keratoplasty and keratectomy are no longer surgical procedures of uncertain results, and a sufficient number of cases have already been studied to determine fairly accurately in which cases these surgical measures will be helpful. The most favorable candidates for keratoplasty are patients with simple central corneal opacities, keratoconus or mild interstitial keratitis. Less favorable subjects for keratoplasty, but still likely to receive considerable improvement in vision are some with corneal dystrophy, shallow, superficial opacities, tear gas burns without vascularization, adherent leukomas, descemetocelles or moderate interstitial keratitis.

Patients who are unfavorable candidates for keratoplasty but who may be partially helped by keratectomy are those with corneal scar extending to the limbus, extensive leukomas, band-shaped opacities, dystrophia adiposa, deep burns of the cornea due to tear gas, extensive tattoo-like corneal opacities caused by explosions and extensive corneal opacities with pannus. Unfavorable for either keratoplasty or keratectomy are patients with corneal opacities in aphakic eyes, Fuchs's epithelial dystrophy, extensive corneal opacities with calcareous degeneration, opacities associated with pemphigus and opacities with extensive anterior synechias. Patients with nystagmus and uncooperative or highstrung patients are unsuitable.

### DISCUSSION

DR WILLIAM H. CRISP, Denver. I should be obliged if Dr. Castroviejo would say something about the cases of extreme keratoconus, rarely seen, in which there are great bulging of the cornea and cloudiness of the apex of the extreme cone.

Would Dr. Castroviejo say a little more as to whether one may expect any gain from roentgen treatment of general vascularity from a tear gas burn many years after the accident has occurred?

DR F. H. VERHOEFF, Boston. I wish to ask Dr. Castroviejo his opinion as to the possibility of recurrence of corneal dystrophy in a graft, and whether in this respect there is any difference in the various types of dystrophy. I know such recurrences have been recorded, and I should like to know whether he thinks its likelihood is great enough to contraindicate keratoplasty.

DR RAMÓN CASTROVIEJO, New York. Dr. Crisp has asked whether an extensive keratoconus is suitable for keratoplasty. If the keratoconus is very extensive but one feels that the whole conus can be replaced by a transplant 6.5 or 7 mm. in diameter, the eye is suitable for keratoplasty. If the conus is so large that in order to replace it a transplant larger than 7 mm. will be required, the operation is likely to be followed by severe complications, such as extensive synechias, leading to secondary glaucoma. In such a case it is advisable to flatten the conus by treating approximately 6 mm. of the center with a fulgurating current applied

with a fine electrolysis needle. After the treatment the eye has to be bandaged with a pressure dressing, which is continued until cicatrization is complete. This treatment causes corneal opacity of the treated area, but the eye is rendered more favorable for keratoplasty when the corneal curvature has been brought within approximately normal limits.

In regard to extensive vascularization of the cornea treated with radiation, my experience has shown that, once the blood vessels have already formed, treatment with roentgen radiation or radium is of no value. Radiation has to be given before the blood vessels have formed. After keratectomy, roentgen treatment is instituted on the same day or on the day after the operation, when the capillaries are beginning to form and they are easily obliterated by radiation. In this way vascularization of the cornea is prevented.

To Dr. Verhoeff's comment on the likelihood of the transplant becoming involved by the cornea of the host affected with dystrophy, it may be said that with some types the dystrophy of the host invariably invades the transplant, such as in Fuchs's dystrophy and dystrophia adiposa corneae. With other dystrophies the transplant is likely to remain transparent.

DR F. H. VERHOEFF, Boston. There is a recurrence of the same type of growth?

DR RAMÓN CASTROVIEJO, New York. Yes, in some cases the transplant is partially or totally involved by a dystrophy of the same type as the host's.

#### Cataract Associated with Intraocular Tumors DR BERNARD SAMUELS, New York

This paper was published in full in a previous issue of the ARCHIVES (35: 366 [April] 1946).

#### DISCUSSION

DR ALEXANDER E. MACDONALD, Toronto, Canada. I wish merely to call attention to an interesting point on one of the slides—a small area, subcapsular, apparently not lined by membrane, but looking like a bleb. I am much interested in these little "blebs" which are frequently visible with the ophthalmoscope in older patients. These small spherical lenticular spaces can hardly be called cystic, and I am anxious to ask Dr. Samuels whether he could suggest a better term, or would he be satisfied with calling them blebs or edema?

DR BERNARD SAMUELS, New York. I should not call them either blebs or edema. I should call them pseudocystic spaces.

#### Intraocular Manifestations of Acute Disseminated Lupus Erythematosus: Report of a Case DR FERDINAND L. P. KOCH, New York, and (by invitation) DR WILLIAM P. MCGUIRE, Winchester, Va.

A case of acute disseminated lupus erythematosus occurring in a 22 year old woman was described. Ophthalmologic examination revealed bilateral retinopathy characterized by numerous superficial retinal hemorrhages, periphlebitis and retinal and choroidal exudates.

The retinopathy became severer as the vasculitis progressed. Normal vascular channels became converted into fibrosed cords, the optic nerve underwent progressive atrophy, and the hemorrhages and exudates gradually decreased. Prior to death, light perception was lost in the right eye and was barely elicitable in the left eye.

The author suggested early and thorough ophthalmoscopic examination in all cases of "fever of unexplained origin."

#### DISCUSSION

DR HENRY P. WAGNER, Rochester, Minn. I think that Dr Koch and Dr McGuire will agree that at times patients presenting themselves solely because of loss of vision show retinal lesions similar to if not identical with the condition they have described. The principal feature of this retinopathy is the perivascular and endovascular inflammatory process which involves the arterioles and veins though at times only the veins, with resultant apparent occlusion of small vascular branches or of segments of the larger vessels. The ophthalmologist "suspects" tuberculosis, thromboangitis obliterans, syphilis or focal infection. But often thorough clinical and laboratory investigations reveal no evidence of any of these diseases in other parts of the body. He is forced to content himself with the diagnosis of inflammatory vascular disease of unknown origin confined to the vessels of the eye. When he is fortunate enough to see these retinal lesions in association with a recognizable systemic disease he is again encouraged to hope that in the future an adequate uniform explanation may be formed for the occurrence of these vascular diseases at times in single and at other times in disseminated locations.

Until recently my own experience with retinal changes in cases of disseminated lupus erythematosus had been confined to the lesions described by Maumence and shown by him to be of nonspecific "toxic" character. A few weeks ago I saw a girl aged 8 years with a condition diagnosed as disseminated lupus erythematosus clinically and confirmed at necropsy. At the time of her admission ophthalmoscopic examination revealed in one eye what I interpreted to be an embolic closure of a small peripheral arteriole, with ischemic edema of the corresponding portion of the retina. One day before death there were numerous apparently embolic, petechiae in each retina with mild edema of the disk and retina similar to the picture seen in subacute bacterial endocarditis. Necropsy revealed definite nonbacterial vegetations on the heart valves. I was unable to secure the eyes for histologic examination.

DR ALEXANDER E. MACDONALD, Toronto, Canada. Patches of exudate were shown in one of the slides. These patches were definitely white, rather than grayish and there were no pigmentary disturbances. It seems to me that choroidal exudate sooner or later is accompanied with pigmentary changes. The white exudate appears to be purely retinal, and I should like to ask whether any pigment appeared in these areas later.

DR FERDINAND L. P. KOCH, New York. It seems a pity that the relatively large number of autopsy reports on this infrequently seen disease have passed over the question of the ophthalmic changes with remarkable uniformity (except for Maumence's report), a fact which is

due primarily, of course, to the lack of understanding that changes in the eyegrounds will occur in this entity

To answer Dr MacDonald's question we do not know whether these exudates were in the choroid or in the retina. Visualization of the fundus in this patient was exceedingly difficult as death approached

### **An Accurate Method for Centering a Front Stop (During Refraction Under Cycloplegia) DR LESLIE C DREWS, St Louis**

The author described a simple device for centering front stops of any desired size in retinoscopy or in cycloplegic refraction. Through the exact center of a +4.00 to +8.00 thin lens is drilled a hole 4 to 5 mm in diameter. If the refractionist is to hold the front stop, a crystal lens may be used, but if the patient is to hold it the lens should be made of cobalt blue glass. A method of centering such a stop entoscopically was also described.

#### **DISCUSSION**

DR WALTER B LANCASTER, Boston. For the problem of the large pupil Dr Drews has offered a solution which works. A patient of reasonable intelligence can readily center the instrument with the cobalt glass, and the operator himself can center the other one if he works within arm's length. It is possible, therefore, to examine a limited area of the pupil either by retinoscopy or by subjective tests. I have not used this test in actual office practice, but the fact remains that it does solve the problem of how to deal with the dilated pupil when a cycloplegic is used. Not using cycloplegic routinely myself, I seldom am confronted with the problem. I should be glad to show how to do refraction without cycloplegia.

DR LESLIE C DREWS, St Louis. I wish to repeat that I do not think this apparatus is of great use in retinoscopy. I think it is of considerable interest and has possibilities in doing cycloplegic refraction.

## Book Reviews

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**Applied Anatomy of the Head and Neck** By Harry H. Shapiro, D.M.D. Second edition, revised and reset. Price, \$10. Pp. 333, with 221 illustrations, 41 in color. Philadelphia: J. B. Lippincott Company, 1947.

This book is especially designed for students and practitioners of dentistry, to relate the anatomy of the head and neck to the various fields of dental work. The anatomic details described are confined to features of most practical significance in diagnosis and treatment in the aforementioned specialty. References to specific cases and applications are interwoven and add greatly to the value of the treatise.

In keeping with the original purpose, the text of the revised edition contains new chapters on the development of the head and neck, the paranasal sinuses, the anatomy of oral infections, and other subjects. The chapters on surface anatomy, interpretation of anatomic landmarks in the roentgenogram of the skull, musculature of the face and jaws and anatomic considerations in maxillofacial war injuries have been enlarged.

The drawings and photographs, some in color, are well reproduced.

The treatise contains material of some value to the ophthalmologist, who not infrequently is called on to express an opinion on a patient's dental problems.

RAYMOND L. PREIFFER

**Eye Surgery** By H. B. Stallard, M.B.E., M.D., F.R.C.S., Price, \$11. Pp. 444, with 338 illustrations. Baltimore: The Williams & Wilkins Company, 1946.

In this informative book, the author sets forth in clear terms his views on most problems of ophthalmic surgery. It is all the more remarkable because it was written during wartime, under the most trying conditions. It is replete with excellent illustrations, most of which were sketched by the author himself. The value of this volume lies largely in its concise portrayal of procedures which have proved useful to this experienced surgeon. As such, it of necessity contains some ideas with which others may disagree, but the vastness of the author's practical knowledge is evidenced by the soundness of his teachings.

The introductory chapter contains much useful information about the layout of an operating room, care of instruments, drugs and pre-operative and postoperative care of patients, as well as wise advice to the surgeon and his staff. The second chapter, devoted to anesthesia and analgesia, is followed by an extensive review of plastic procedures. In this section, the author's wide experience with war injuries is given in graphic form, with numerous photographs taken before and after operation, together with a description of the reconstructive methods used. While the discussion contains little that is new or original, many valuable details on suturing, technic and postoperative care are included. In his discussion on ptosis, to the reviewer's surprise, there is no men-

tion of the Dickey operation. The chapter on the lacrimal apparatus contains an account of the usual operations and, in addition, a description of a procedure called "conjunctivo-dacryocystostomy." In this operation the fundus of the freed lacrimal sac is sutured to the edge of a conjunctival incision made in the lacus lacrimalis. The author conservatively concludes this description with these words, "However, in spite of a good opening, drainage of tears is not so satisfactory as through the normal channels."

In the chapter on extraocular muscle surgery, one finds a perpetration of the usual error in referring to removal of a portion of the inferior oblique as a myomectomy, instead of a myectomy. His preference for use of the so-called guarded tenotomy in young children is not generally shared, nor do most surgeons feel it necessary to cover both eyes for eight to ten days after operations on muscles.

In the discussion on keratoplasty, a proper conservative attitude is adopted toward this operation. Castroviejo's technic is that originally described by this author, but one he no longer uses.

The chapters on intraocular surgery include descriptions of the usual procedures, with many interesting personal comments on technic, indications and complications. The corneoscleral suture, for which the author is well known, is described in detail, as is his technic of implantation of radon seeds in the treatment of intraocular neoplasms. In the chapter on traumatic surgery there is an excellent account of the technic employed in extracting an intraocular foreign body by the posterior route. The extreme care with which every detail of each operative procedure is described makes this book a most valuable one for the average ophthalmic surgeon. Its popularity will be justifiably great, for it is lucidly written, well printed and clearly illustrated.

JOHN H. DUNNINGTON, M.D.

**Transactions of the American Ophthalmological Society: Eighty-first Annual Meeting, Hot Springs, Va., 1945. Vol. XLIII. Pp. 644. Philadelphia: American Ophthalmological Society, 1945.**

These transactions bring a report of the Eighty-First Annual meeting of the American Ophthalmological Society, which was held at Hot Springs, Va., on Nov. 12 to 14, 1945, with Dr. S. Judd Beach, president, in the chair. The meeting of the year 1945 was postponed until the fall, owing to the Government restrictions on railroad travel. Nevertheless, the attendance was unusually large, and the society was honored with the presence of Prof. Ida Mann, of Oxford, England. The scientific program consisted of twenty-three papers. Dr. H. P. Wagener, Rochester, Minn., presented the report of the Committee on the Classification of Hypertensive Diseases of the Retina. A number of new instruments were exhibited, and the theses of 6 successful candidates are added, making in all an imposing volume of 644 pages.

The editor, Dr. Wilfred E. Fry, of Philadelphia, deserves the thanks of the members of the American Ophthalmological Society for this successful volume.

ARNOLD KNAPP



**Transaction of the American Ophthalmological Society** Vol XLIV  
Pp 554 Philadelphia American Ophthalmological Society, 1946

This volume of 554 pages, brings a report of the eighty-second annual meeting of the society held at San Francisco, June 26 to 28, 1946, under the presidency of Dr Eugene M Blake, of New Haven, Conn. Twenty-four papers were presented and discussed. Five new members were elected, their names and the subject of their theses were as follows: Dr William B Anderson, Durham, N C "Observation on Corneal and Conjunctival Pigmentation Occurring Among Workers Engaged in the Manufacture of Hydroquinone", Dr Hugo Ban, Rochester, Minn, "Analysis and Interpretation of Anomalous Localization and Allied Phenomena Associated with Strabismus", Dr Harold Giftord Omaha, "A Study of the Vitreous Pressure in Cataract Surgery", Dr David O Harrington, San Francisco "The Autonomic Nervous System in Ocular Diseases" and Dr William P McGuire, Winchester, Va. "Surgical Correction of Paresis of the Superior Oblique". The volume contained obituaries of Drs Ellice M Alger, J Wilkinson Jervey, Edward Stieren E Eugene Holt Jr, Cassius D Wescott and James Watson White, members who died during the preceding year.

Eighty-two members attended the meeting, and there were many guests. Sir Stewart Duke-Elder of London was present and spoke on "Ophthalmology During the War and in the Future". Sir Stewart was elected to honorary membership and received the Howe medal for 1946.

ARNOLD KNAPP

**A Scientific Method of Fitting Contact Glasses** By Philip L Salvatori  
Price, \$3.75 Pp 170, with 86 figures and photographs, 8 in color  
Privately printed, 1947

Mr Salvatori was trained by Theodore Obig, but this book is, perhaps intentionally, much more superficial than Obig's classic work (Obig, T. Contact Lenses, ARCH OPHTH 28:568 [Sept] 1942). The author is apparently a skilful and experienced technician, and his descriptions of the molding, casting and fitting procedures are aided by excellent photographs and diagrams. The methods discussed are well known, and nothing will be gained by abstracting them here.

It is not easy to determine for what professional level the book is intended. Perhaps the answer may be surmised from the glossary at the end. Here the reader will learn that anterior means "in front of," that medial means "pertaining to the middle" and that an opaque object "does not permit the passage of light." Putting in a contact glass is known as its "insertion," and the reader who wishes to know what taking it out is called has only to look up the word "removal." However, it is not as a literary technician that Mr Salvatori should be judged, and his laboratory skill is evident enough.

G M BRUCE

## SURGICAL TREATMENT OF SYPHILITIC PRIMARY ATROPHY OF THE OPTIC NERVES (SYPHILITIC OPTOCHIASMATIC ARACHNOIDITIS)

A Clinicoanatomic Study

WALTER L. BRUETSCH, M.D.  
INDIANAPOLIS

OF LATE a number of publications have appeared on the surgical treatment of syphilitic primary atrophy of the optic nerves.<sup>1</sup> Neurosurgical intervention in treatment of this condition is based on the recently advanced theory that syphilitic arachnoiditis, involving the optic nerves, produces atrophy of the nerves. The purpose of the operation is to free the optic nerves of the adhesions believed responsible for pressure and constriction, which is followed by atrophy of the nerves.

In the past other hypotheses of the pathogenesis of primary syphilitic optic nerve atrophy, formerly called tabetic optic nerve atrophy, have been advanced. The earliest theory placed the essential lesion in the ganglion cells of the retina. Some investigators expressed the belief that the atrophy originated as a primary degeneration of the nerve fibers. The "retinal theory" was disproved by the work of Léri,<sup>2</sup> who, on the basis of the histologic examination of a large anatomic material, expressed the view that the primary lesion of tabetic atrophy of the optic nerve consists in an interstitial neuritis. Similar conclusions were reached by

This study was aided by a grant from the American Society for the Prevention of Blindness and the American Social Hygiene Association.

From the Research Department, Central State Hospital, and from the Department of Neurology and Psychiatry, Indiana University School of Medicine.

1 (a) Vincent, C., Jeandelize, and Bretagne. *Atrophie optique tabétique et neuro-chirurgie*, Bull Soc d'ophth de Paris **49** 245, 1937. (b) Vail, D. *Syphilitic Optochiasmatic Arachnoiditis*, Am J Ophth **22** 505, 1939. (c) Hausman, L. *Blindness Due to Syphilitic Arachnoiditis of the Optic Nerves and Chiasm Restoration of Vision Following Surgical Intervention*, Tr Am Neurol A **65** 181, 1939. (d) *Syphilitic Atrophy of the Optic Nerve and Papilledema Due to Optochiasmal Arachnoiditis. Indications for Surgical Intervention*, Arch Ophth **23** 1107 (May) 1940. (e) *The Surgical Treatment of Syphilitic Optic Atrophy Due to Chiasmal Arachnoiditis*, Am J Ophth **24** 119, 1941. (f) Schaub, C. F. *Surgical Treatment of Syphilitic Optic Atrophy (Syphilitic Optico-Chiasmatic Arachnoiditis)*, Dis Eye, Ear, Nose & Throat **1** 326, 1941.

2 Léri, A. *Étude de la rétine dans l'amaurose tabétique*, Nouv iconog de la Salpêtrière **17** 304, 1904. *Étude du nerf optique dans l'amaurose tabétique*, ibid **17** 358, 1904.

The etiologic factor in optochiasmatic arachnoiditis remains obscure in most cases,<sup>11</sup> except in those which follow otitis media and a syphilitic infection. In most other cases with symptoms of optochiasmatic arachnoiditis there is apparently a process within the optic chiasm, either inflammatory or demyelinating, involving the nerve fibers and the arachnoid at the same time.

#### SYPHILITIC OPTOCHIASMATIC ARACHNOIDITIS

In the discussion of optochiasmatic arachnoiditis syphilis has only of late received consideration. In most cases in which an exploration of the chiasm was performed the process was of nonsyphilitic origin. Only since 1934 has syphilis been given the prominent role which it deserves in the causation of arachnoiditis, although it occurs mostly in asymptomatic form.<sup>11</sup> Subsequently, from a neurosurgical standpoint, its importance has been overemphasized, for the idea has been accepted widely that syphilitic arachnoiditis, involving the optic nerves, is responsible for syphilitic primary optic nerve atrophy.

Probably the first to operate for syphilitic primary optic nerve atrophy was Cushing.<sup>12</sup> In 1930, in a series of other cases, he reported the history of a patient aged 39 with progressive failure of vision of three years' standing, bitemporal field defects and large central scotomas. The optic disks showed grayish atrophy. Vision was 2/200 in the left eye and 20/50 in the right eye. The patient had a history of possible congenital syphilitic infection, for which he had not been treated. The Wassermann test of the blood gave a negative reaction, but the lumbar spinal fluid showed a trace of globulin, 7 cells per cubic millimeter and slightly positive Wassermann and Kahn reactions. Except for the ophthalmologic findings, the physical examination was wholly without significance. The patient was first placed under routine antisyphilitic treatment, but vision kept on failing. It was then thought that the condition was due to a tumor, and operation was advised. Exploration disclosed that the chiasm was embedded in a distinctly thickened and grayish arachnoid, containing a great excess of fluid. The patient made a perfect recovery from the operation, but there was no improvement in vision.

Cushing, with his keen judgment, recognized at once the reason for the lack of visual improvement in this case. The cause, as he explained it, may lie in the fact that the same process which caused the thickening of the pia-arachnoid likewise affected and permanently damaged the optic nerves. His assumption proved to be correct, as will be shown in the present study, which was directed toward the solution of this question.

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11 Bruetsch, W. L. The Etiology of Optochiasmatic Arachnoiditis, *Arch Neurol & Psychiat*, to be published.

12 Cushing, H. The Chiasmal Syndrome of Primary Optic Atrophy and Bitemporal Field Defects in Adults with a Normal Sella Turcica, *Arch Ophthalm* 3: 505 (May), 704 (June) 1930.

## REPORT OF CASES

CASE 1—*Primary syphilitic optic nerve atrophy occurring in a patient with tabes dorsalis, syphilitic optochiasmatic arachnoiditis as a possible cause of atrophy of the optic nerves*

*History*—The patient had had a chancre at the age of 18. Twenty years later he experienced the first shooting pains. During the next year he became aware of obscuration of vision. This led him to consult a physician, who gave him five injections of neoarsphenamine. This was the first time that he received any treatment for syphilis. Vision decreased steadily, and within one year he was completely blind. Gastric crises then developed. Several years later he began to have difficulty in walking, and at the age of 57 he had completely lost control of both lower extremities.

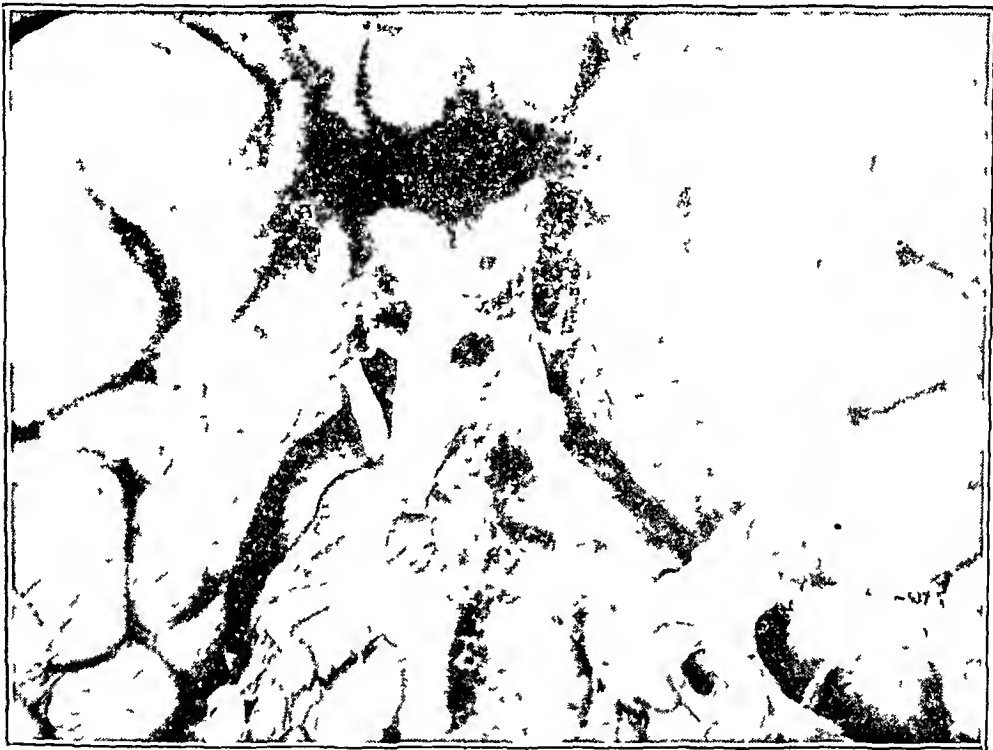


Fig 1 (case 1)—Primary syphilitic atrophy of the optic nerves in a tabetic patient. Arachnoidal bands (syphilitic optochiasmatic arachnoiditis) extend from the pons and insert on both optic nerves in front of the chiasm.

*Physical Examination*—The patient, aged 57, was totally blind. He could not perceive even a very bright light with either eye. Both optic disks were chalky white. The other neurologic signs were typical of tabes dorsalis. Memory was good, and there was no psychosis. The Wassermann, Kahn and Kline reactions of the blood were negative. The Wassermann reaction of the spinal fluid was positive. The cell count of the fluid was 3 cells per cubic millimeter, and the Ross-Jones and Pandy test gave weakly positive reactions. The colloidal gold curve was 0123321000.

The patient was given a course of malaria therapy, without improvement in sight or gait.

He died three months after admission to the hospital, of tuberculous spondylitis and pulmonary tuberculosis.

*Postmortem Observations*—Firm arachnoidal adhesions originated in the middle portion of the pons and inserted on both optic nerves, immediately in front of the chiasm (fig 1). Both third nerves emerged outside the adhesions. The thickened arachnoidal bands pulled the optic nerves and the optic chiasm backward, suggesting that during life traction was exerted on both nerves. The volume of the optic nerves was reduced to about one-half or less that of the normal nerve. Atrophy of the left optic nerve was even greater. At the site of insertion of the arachnoidal band on the left optic nerve there occurred a kink. Here the optic nerve fibers had almost entirely vanished.

The capsular surface of the hypophysis was thickened, giving the impression that at one time an intense inflammatory process had taken place about the optic chiasm and the hypophysis.



Fig 2 (case 1)—Thickened optochiasmatic arachnoid passing over the atrophic optic nerve. Hematoxylin-eosin stain,  $\times 50$ .

*Histologic Examination*—Examination of the arachnoidal adhesions about the chiasm revealed a thickened membrane, consisting of several rows of proliferated arachnoidal cells. Next occurred an increased number of fibroblasts, which had produced a thickened layer of connective tissue (fig 2). There were no round cell infiltrations or vessels showing syphilitic endarteritis. No spirochetes were observed in the thickened optochiasmatic arachnoid.

Both optic nerves, the optic chiasm and the optic tracts showed complete demyelination (atrophy). In some portions of the pia of the intracranial portion of the optic nerves a few scattered round cells were present. In the trabecular connective tissue of the interior of the intracranial portion of the optic nerves 1 plasma cell was noted in every third oil immersion field. *Treponema pallidum* was not identified in the optic nerves.

In the pia of the floor of the third ventricle and in other areas at the base of the brain plasma cells were arranged in single file. No such infiltration of plasma cells was present in the meninges over the upper aspect of the brain. The cerebral cortex was free of perivascular infiltrations, i.e., of changes characteristic of dementia paralytica.

The posterior columns of the spinal cord showed degeneration, characteristic of tabes.

*Comment*—When I saw the base of this brain in 1932, I was convinced that the "tabetic optic nerve atrophy" in this case was the result of arachnoidal adhesions and that blindness could have been prevented by surgical intervention. I had this case in mind when I recommended surgical treatment for optic nerve atrophy in the discussion on the paper by Moore and Woods,<sup>13</sup> read before the Association of American Physicians in 1938. I did not publish the case because I wanted to collect other instances of syphilitic atrophy of the optic nerve. I began to accumulate anatomic material, not only of syphilitic atrophy of the optic nerves but also of atrophies caused by such conditions as brain tumor, multiple sclerosis and Schilder's disease. To form a sound judgment on the mechanism of degeneration of the nerve fibers in cases of optic nerve atrophy, which varies with the etiologic factor involved, it was necessary to examine histologically a large material of atrophies of the optic nerve of various causes.

Today I am no longer certain that the arachnoidal adhesions were the sole cause of the atrophy of the optic nerves in the case just described. Two reasons changed my mind. First, the intracranial portion of the optic nerves showed complete demyelination. If demyelination had been due to traction or pressure alone, i.e., to mechanical effects, areas with normal nerve fibers would have been left. Second, in the pia at the base of the brain there was a mild degree of plasma cell infiltration, indicating that basically the atrophy in this case had its origin in chronic basilar syphilitic meningitis, as it has in other instances of primary syphilitic atrophy of the optic nerves. In the intracranial portion of the optic nerves, in the chiasm and even more so within the optic tracts an occasional plasma cell was observed. This observation, however, cannot be given too much weight in the argument, because a few scattered plasma cells and lymphocytes are occasionally present within the optic nerves, the chiasm and the optic tracts of neurosyphilitic patients who do not have optic nerve atrophy. Furthermore, seventeen years had passed since the patient had become blind. It is obvious that during this period the degree of plasma cell infiltration at the base of the brain and within the optic nerves had undergone a reduction, adding to the difficulties of correct interpretation of the histologic observations.

<sup>13</sup> Moore J. E., Woods, A. C., Hopkins, H. H., and Sloan, L. L. The Treatment of Syphilitic Primary Optic Atrophy, JAMA 111 385 (July 30) 1938.

**CASE 2**—*Development of atrophy of the optic nerves and bilateral ptosis in a patient with dementia paralytica four years after malarial therapy, in spite of rapid improvement in the spinal fluid. Optic nerve atrophy and involvement of the cranial nerves were assumed to be caused by syphilitic optochiasmatic arachnoiditis. The poor health of the patient prohibited surgical intervention. Necropsy revealed the striking absence of arachnoidal adhesions in the chiasmic region.*

**History**—A woman aged 47 was admitted on July 26, 1928, with clinical and serologic signs of dementia paralytica. There were no complaints of failing vision. She was given a course of tertian malaria therapy, experiencing nine elevations of temperature, ranging from 101 to 104 F. After malarial therapy the acute mental symptoms of dementia paralytica subsided, but there was slowly progressing mental deterioration. For about two years after malarial therapy there was no obvious indication that her eyesight was failing. Then, in 1930, it was noted that she had difficulty in getting about the ward. At the same time, bilateral ptosis and paralysis of the left sixth nerve developed (fig 3). Within one year, however, the ptosis improved considerably. At the end of 1932 vision had become reduced to a point at which the patient could perceive only strong light before her eyes. Owing to the deteriorated mental stage, examination of the visual fields was always unsatisfactory.



Fig 3 (case 2)—Face of the patient with primary syphilitic atrophy of the optic nerves, accompanied with involvement of the third and sixth cranial nerves (ptosis and internal strabismus of the left eye). See figure 4, which shows the base of the brain of this patient.

Strikingly the rapid loss of vision became noticeable during a time when there was pronounced improvement in the spinal fluid. In the two years following malarial therapy, the findings in the spinal fluid indicative of dementia paralytica remained unchanged except for the cell count. In the next three years, from 1930 to 1933, there was a complete return to normal of all reactions, including the Wassermann reaction, the cell count, the total protein content and the colloidal gold reaction.

In the succeeding years the patient became bedfast, sacral ulcers developed, and she died in 1940, of pyelonephritis.

**Postmortem Observations**—Except for a few delicate strands of arachnoid passing over the right optic nerve, there were no arachnoidal adhesions in the optochiasmatic region (fig 4). About the exit of both third nerves the pia-arachnoid revealed moderate thickening. The optic nerves had a grayish appearance and were reduced in size. Both third nerves were atrophied, having less than one-half the volume of a normal oculomotor nerve.

**Histologic Examination**—There was complete gray atrophy (demyelination) of the optic nerves, optic chiasm (fig 5) and optic tracts, giving the impression of "primary parenchymatous degeneration" of the nerve fibers. However, careful search revealed slight residual inflammatory changes in the form of scattered

foci of plasma cells and lymphocytes in isolated areas of the periphery of the optic nerves and chiasm (fig 6) The visual pathways were examined for T pallidum, but no organisms were seen In the interior of the intracranial portion of the optic nerves and within the chiasm, about small vessels, from 2 to 5 plasma cells were noted in some oil immersion fields, while other fields were free of such



Fig 4 (case 2)—Base of the brain of a patient with syphilitic atrophy of the optic nerves, revealing complete absence of optochiasmatic adhesions Arrows point to the atrophied third nerves

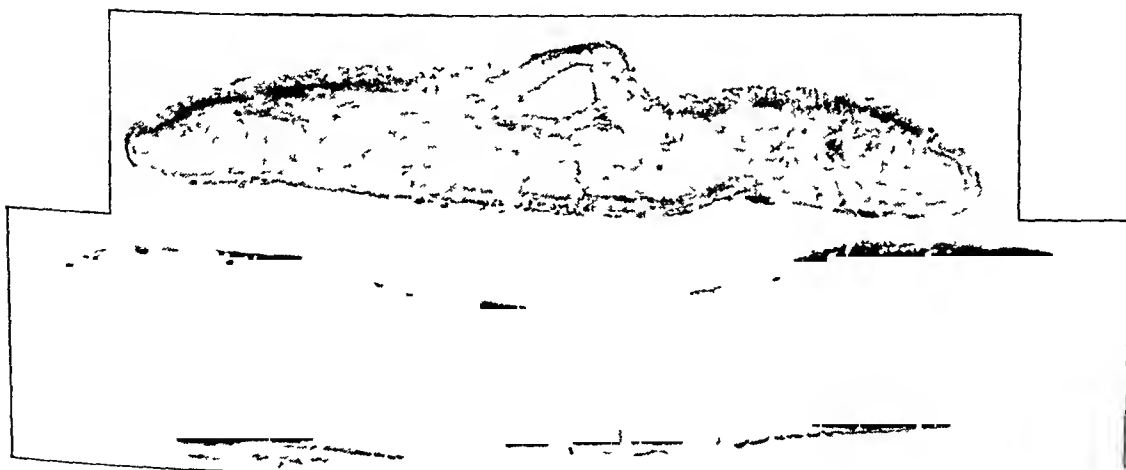


Fig 5 (case 2)—Complete gray atrophy of the optic chiasm, Weil stain for myelin sheaths,  $\times 7$  The lower picture represents a normal optic chiasm, stained with the same stain and photographed with the same magnification for comparison

cells There were also enlarged perivascular spaces, although now empty of round cells, suggesting that at one time the exudative process had been much more intense



In the orbital convolutions and over the pons the pia-arachnoid was practically normal, and only on intensive search could a few isolated round cells be detected. In other words, there was more round cell infiltration in the pia of the intracranial portion of the optic nerves than in other areas of the base of the brain.

**Third Nerves** The pia of the third nerves was normal, but in the interior of the nerves plasma cells were more frequent than within the optic nerves. Some of the nerve fibers were partially demyelinated. The loss of myelin was more pronounced in the right than in the left third nerve. The ganglion cells of the nuclei of the third nerves were normal.

In the cerebral cortex the perivascular infiltrations had completely receded, leaving no trace of dementia paralytica evident even to the experienced observer.

The posterior columns of the cord showed a slight degree of degeneration of the tabetic type.

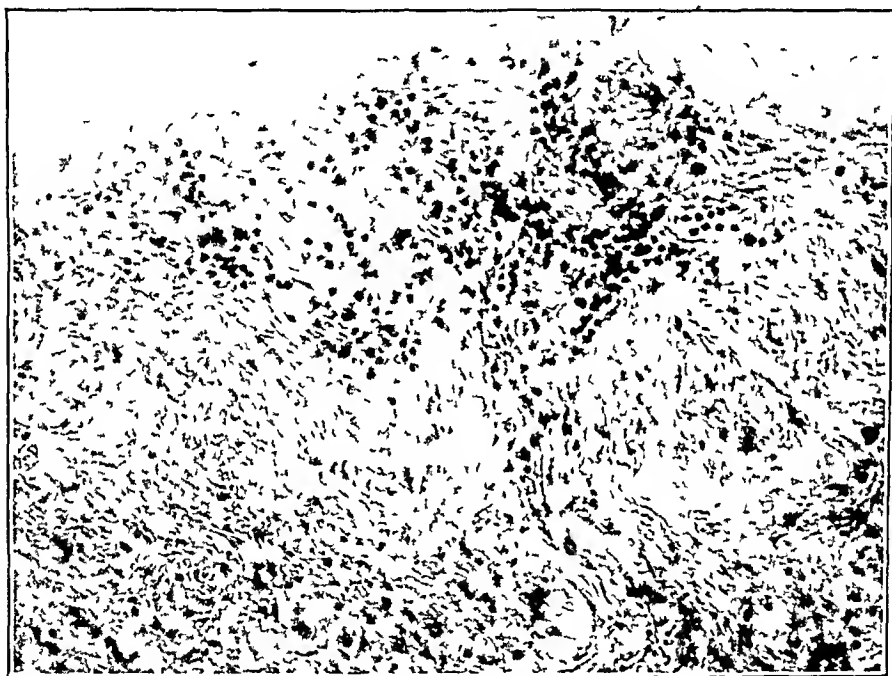


Fig 6 (case 2) —Residual focus with plasma cells and lymphocytes in the pia of the intracranial portion of the atrophied optic nerve, persisting in spite of an entirely normal spinal fluid. Toluidine blue stain,  $\times 225$ .

*Comment*—In this case atrophy of the optic nerve developed slowly in the years following malarial therapy, and at a time when the spinal fluid findings were returning to normal. It was argued that contracting arachnoidal adhesions at the chiasm were the cause of the atrophy of the optic nerves. This belief was strengthened by the appearance of changes in the third and sixth cranial nerves, which were thought to be caused by the same arachnoidal adhesions. Exploration of the chiasm was considered, but the patient's poor state of health prohibited surgical intervention. At autopsy, the complete absence of arachnoidal adhesions at the base of the brain came as a surprise. Prior to death

much weight was given to Hausman's<sup>14</sup> statement that the diagnosis of syphilitic chiasmatic arachnoiditis should be considered when, in addition to atrophy of the optic nerves, there is involvement of other cranial nerves. This assertion is logical, for syphilitic arachnoiditis is usually not confined to the chiasm, but involves the entire base of the brain.

How, then, can one explain the occurrence of optic nerve atrophy and ptosis in the presence of an interpeduncular space entirely free of arachnoidal adhesions, and developing after an otherwise successful course of malarial therapy, as evidenced by improvement in the spinal fluid? Microscopic examination furnished the clue. The atrophy of the optic nerves in this case finds its explanation in the now definitely established theory that degeneration of the nerves occurs as the result of an inflammatory process within the nerves and the chiasm.

Therapeutic malaria cleared up the inflammatory process in the cerebral cortex but did not influence materially the round cell infiltration at the periphery of and within the optic nerves. There the inflammation continued, advancing slowly in the course of several years from the periphery toward the center of the nerves. That this sequence of events had taken place was substantiated by the observation that at the periphery of the optic nerves as well as within the septal connective tissue plasma cells could still be seen. In addition, in the interior of the chiasm were vessels surrounded with enlarged perivascular spaces, giving evidence that at one time rather heavy perivascular infiltrations were present.

An important point of clinical interest is the circumstance that all tests of the spinal fluid, including the Wassermann test, cell count, determination of the total protein and colloidal gold test, gave entirely normal results for five years prior to death. Yet histologic examination revealed that a slight exudative process was still present (fig 6). This brings out the hitherto unsuspected fact that in spite of a completely normal spinal fluid a mild inflammation may persist about and within the optic nerves.

The ptosis is explained on a similar basis, namely, persistence of interstitial neuritis of the third nerves, leading to demyelination. Later, the inflammatory phenomena subsided, with restoration of partial function. The excellent regenerative ability of the third nerves was demonstrated experimentally in chimpanzees, in which functional recovery in ocular muscles took place after section of the oculomotor nerve.<sup>15</sup>

14 Hausman, L. Relation of Syphilitic Optic Atrophy and Papilledema to Adhesions at the Chiasm. Indications for and Results of Surgical Treatment, *Arch Neurol & Psychiat* **43** 1034 (May) 1940.

15 Bender, M. B., and Fulton, J. F. Functional Recovery in Ocular Muscles of a Chimpanzee After Section of Oculomotor Nerve, *J Neurophysiol* **1** 144, 1938.

*CASE 3—Isolated syphilitic primary atrophy of the optic nerves associated with involvement of the third and sixth cranial nerves, followed by development of dementia paralytica of tabetic type. Autopsy revealed syphilitic arachnoiditis involving the optic nerves, the chiasm and the third and sixth nerves. Surgical removal of arachnoidal adhesions would have been without avail, because the thickened arachnoid passed harmlessly over the chiasm and the diffuse infiltration of plasma cells within the optic nerves and the chiasm would have persisted.*

*History*—A man aged 50, while operating a punch card machine, noticed that his eyesight was failing. Within the next four and one-half years impairment of vision progressed to total blindness. Six months later he became forgetful and exhibited paranoid tendencies toward his family, necessitating commitment to an institution.

*Physical Examination*—The patient was totally blind. He could not perceive a flashlight immediately before his eyes. Both lids drooped, and the left eye was turned inward (fig 7). Both pupils were in mid-dilatation, of equal size, slightly irregular in outline, and fixed to light. Both optic disks had sharp outlines and were distinctly atrophic.



Fig 7 (case 3)—Face of patient with primary syphilitic atrophy of the optic nerves, associated with partial ptosis and internal strabismus of the left eye (involvement of the third and sixth nerves), followed five years later by dementia paralytica of tabetic form. Figure 8 shows the optochiasmatic region of this patient.

Hearing was diminished on the right side. The patellar reflex was absent bilaterally. The patient was unable to walk, and gait could not be tested. There was incontinence of urine. Mental deterioration was evident.

Examination of the lumbar cerebrospinal fluid showed a positive Wassermann reaction, a trace of globulin, 17 cells per cubic millimeter and a colloidal gold curve of 4443321000. The Wassermann, Kahn and Kline reactions of the blood were positive.

The patient died eighteen months after admission, of bronchopneumonia.

*Postmortem Examination*—On elevation of the frontal lobes of the brain, a thickened arachnoid was noted, which extended along both optic nerves to the optic foramina. The brain was carefully removed without disturbing the arachnoidal adhesions. Examination of the base of the brain revealed syphilitic arachnoiditis (fig 8). The thickened arachnoid extended from the pons, embedded tightly both third nerves, surrounded the internal carotid arteries and continued to the optic chiasm. A thick arachnoidal band stretched over the right optic nerve and ter-

minated in front of the chiasm. There was no pressure indentation in the right optic nerve of the type that has been described and sketched by investigators of this subject<sup>16</sup>. Both optic nerves were somewhat reduced in size, but the diagnosis of atrophy of the nerves could not be made with certainty from the gross appearance of the nerves, which were of fairly good volume. The third nerves were definitely atrophied and emerged through the fibrosed arachnoid. The pia-arachnoid over the tip of both temporal lobes and over the anterior portion of the orbital region was transparent.

*Microscopic Examination*—The myelin sheath preparations showed complete gray atrophy of both optic nerves, with no remaining normal nerve fibers (fig 9). The atrophy was also complete in the chiasm and in the optic tracts. In the pia of the intracranial portion of both optic nerves there were round cell infiltrations, which in isolated places formed massive foci and penetrated toward the interior (fig 10). Throughout the entire diameter of the intracranial portion of both optic



Fig 8 (case 3) —Primary syphilitic atrophy of the optic nerves with syphilitic optochiasmatic arachnoiditis. The thickened arachnoid embraces both third nerves (arrows) and internal carotid arteries and continues over the chiasm to the orbital convolutions.

nerves there was moderate plasma cell infiltration, occurring mostly about small vessels and capillaries. The plasma cells were arranged in single file and could not be seen with low power magnification, such as that in figure 10. A similar but more intense, inflammatory process prevailed about and within the chiasm, where plasma cells and lymphocytes were scattered everywhere. Sometimes in one oil immersion field as many as 10 plasma cells could be observed. In other words in the optic nerves, in the chiasm and, to a lesser degree, in the optic tracts there was an interstitial neuritis. Spirochetes were not observed in the structures of the visual pathways.

<sup>16</sup> Rea, R. L. *Neuro-Ophthalmology*, St. Louis, C. V. Mosby Company, 1941, p. 591.

**Optochiasmatic Arachnoid** At no place did the arachnoid have a constricting or pulling effect on the optic nerves, the chiasm or the third nerves. The thickened arachnoid was diffusely infiltrated in its entire width with lymphocytes and plasma cells.

There was a similar round cell infiltration in the pia of the stalk of the hypophysis, and even within the stalk plasma cells were present in diffuse fashion.

In the pia at the base of the brain, adjacent to the chiasm, round cell infiltration was slight, while, in contrast, in the pia of the chiasm the inflammatory process was much more intense. A few vessels at the base of the brain exhibited syphilitic panarteritis.

In the cortex of the orbital and temporal lobes and in the gray matter extending upward as far as the island of Reil there were slight perivascular infiltrations,

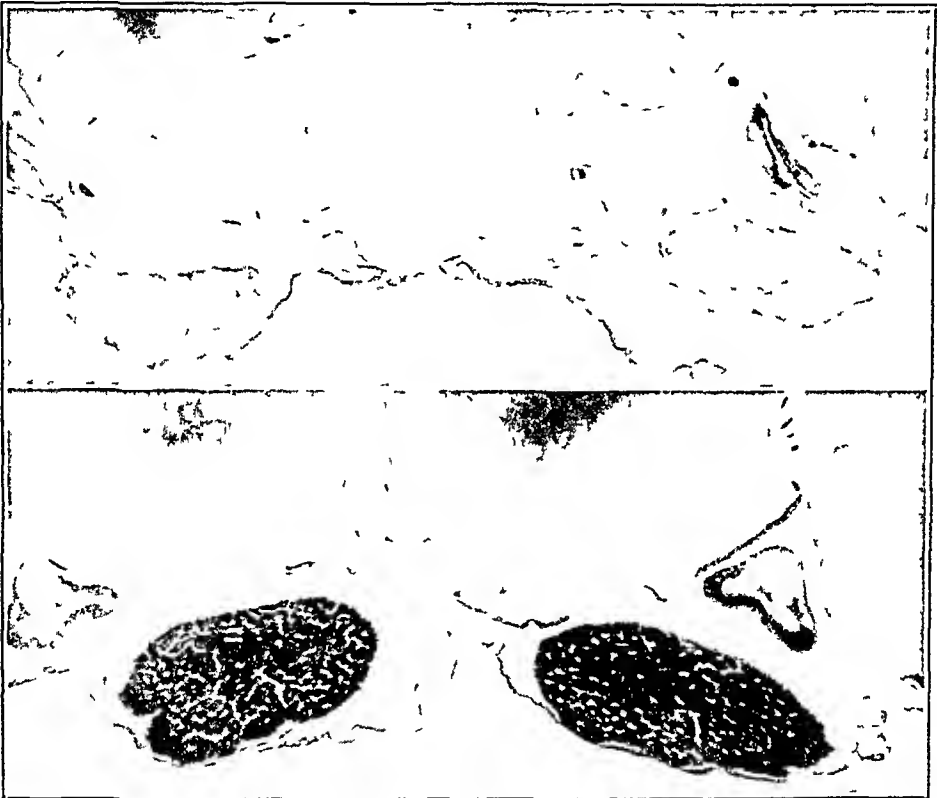


Fig 9 (case 3)—Complete gray atrophy of both optic nerves. Note the arachnoid passing harmlessly over the optic nerves. Weil myelin sheath stain,  $\times 5\frac{1}{2}$ . The lower picture shows normal optic nerves, stained with the same stain, for comparison.

but in the upper part of the brain the cortex was strikingly free of exudative changes.

**Third Nerves** Around the periphery of the third nerves there was definite round cell infiltration. Everywhere in the interior of the third nerves were numerous plasma cells, averaging from 15 to 20 in one oil immersion field. The oculomotor nerves disclosed a considerable degree of demyelination. The arachnoid, which was diffusely infiltrated with round cells, passed over the third nerves without compressing the nerve structures. The nuclei of both third nerves were normal.

In the spinal cord was moderate degeneration of the posterior columns.



Fig 10 (case 3) —Intracranial portion of the optic nerve with massive inflammatory focus penetrating from the margin toward the interior. Throughout the entire diameter of the optic nerve there is plasma cell infiltration, which cannot be seen with this low magnification. Toluidine blue stain,  $\times 75$



Fig 11 —Asymptomatic, syphilitic optochiasmatic arachnoiditis without optic nerve atrophy

*Comment*—If at an earlier stage of the atrophy of the optic nerves in this case the chiasm had been explored, the surgeon would have noted thick arachnoidal adhesions. However, the surgical removal of the thickened optochiasmatic arachnoid would have been without benefit, for the inflammatory process within the optic nerves and chiasm would have continued.

The accompanying involvement of the third and sixth nerves had suggested that basilar arachnoiditis produced ptosis and internal strabismus as a result of mechanical pressure. The gross appearance of the base of the brain also seemed to substantiate this clinical interpretation. Microscopic examination corrected this impression, showing that the atrophy of both third nerves was the result of an interstitial neuritis. In summary, one may say that the same inflammatory process which had produced the atrophy of the optic nerves had caused the atrophy of the third nerves. The thickening of the arachnoid was only secondary to the existing basilar meningitis, and was of no essential consequence in the causation of the nerve atrophies.

#### COMMENT

In addition to the 3 cases reported in this paper, 9 other instances of syphilitic atrophy of the optic nerves formed the material of this study. In none of the cases, with the possible exception of case 1, was there any anatomic evidence that the arachnoidal adhesions, if they were present at all, were the cause of the atrophy of the optic nerves. In case 1, at the time of the gross inspection, it appeared that the arachnoidal fibrosis had exerted a pulling effect on the optic nerves, causing mechanical atrophy of the nerve fibers. Histologic examination, however, indicated that the atrophy of the optic nerves, as in all the other cases, was very likely the result of an interstitial neuritis. After the optic nerves had wasted and the fibrosed arachnoid had contracted, the arachnoidal bands pulled back the atrophied nerves and created a condition which at first sight was suggestive of a mechanical cause of the atrophy.

#### THE MECHANICAL THEORY OF OPTIC NERVE ATROPHY

What convinced me most that the optochiasmatic adhesions of syphilis are not the cause of optic nerve atrophy was a study of the effect of pressure which was exerted directly by tumors on the optic nerves. Contrary to common belief, the optic nerves are tough structures, which can withstand much pressure without undergoing generalized atrophy. The histologic picture of pressure atrophy of the optic nerves is entirely different from that of syphilitic atrophy of the nerves. In the case of optic nerve atrophy due to direct pressure one finds peripheral and other circumscribed areas of normal-staining nerve fibers although the

optic nerves may have been reduced to ribbons. In the case of complete syphilitic optic nerve atrophy no normal nerve fibers are left, and the optic nerves may have retained a fairly good volume. If the atrophy associated with syphilis is not complete, the preserved tissue is usually situated in the center of the nerve, indicating that the interstitial neuritis, which progresses from the margin, has not yet reached the centrally located nerve fibers.

#### FREQUENCY OF OPTOCHIASMATIC ARACHNOIDITIS ASSOCIATED WITH SYPHILITIC PRIMARY ATROPHY OF THE OPTIC NERVES

In making explorations of the chiasm in cases of syphilitic atrophy of the optic nerves, some operators reported the consistent presence of arachnoidal adhesions, while others failed to observe pathologic arachnoidal bands. From these reports one gains the impression that neurosurgeons have little conception as to what is a normal and what is an abnormal arachnoid. Fine bands of arachnoid arising from the neighboring arteries and stretching over the optic nerves and chiasm are frequently present and are a normal variant of the chiasmatic cistern. Throughout the present study special attention was given to the state of the optochiasmatic arachnoid. Of 12 cases of syphilitic optic nerve atrophy the interpeduncular space was entirely free in 4, or 33 per cent. In 2 cases, or 17 per cent, there was slight arachnoidal thickening, which was not outside possible physiologic limitations. In the remaining 50 per cent there was increased thickening of the arachnoid, which permitted the diagnosis of syphilitic optochiasmatic arachnoiditis. In none of my cases had the arachnoid assumed the thickness shown in the 2 photographs illustrating nonsyphilitic arachnoiditis presented by Horrax.<sup>6</sup>

In a series of 100 cases of dementia paralytica without optic nerve atrophy there was a somewhat similar, but in one respect significantly different, percentage as to the presence or absence of thickening of the optochiasmatic arachnoid. In 27 per cent of the cases the base of the brain was free of arachnoidal adhesions. In 52 per cent the arachnoid was somewhat thickened, but was possibly still within normal limits. Only in 21 per cent was there unmistakable optochiasmatic arachnoiditis. This figure is in contrast to the 50 per cent in cases of syphilitic optic nerve atrophy. This observation could be interpreted as indicating that in patients with optic nerve atrophy there is generally a higher degree of meningitis at the base of the brain than in neurosyphilitic patients without optic atrophy. This interpretation would accord well with the idea that optic nerve atrophy is the result of basilar syphilitic meningitis. However, the decisive factor in the genesis of optic nerve atrophy is not the mechanical effect of arachnoidal thickening, rather, it is the inflammatory process, and whether this process



penetrates into the optic nerves or the exudative phenomenon remains confined to the pia and arachnoid. The importance of this factor is illustrated by the cases of neurosyphilis without optic atrophy. In figure 11 one sees arachnoidal adhesions which are as thick as those in cases of optic nerve atrophy. Yet in this case there was no atrophy of the optic nerves, for the round cells, which were present in the pia and arachnoid, had not invaded the interior of the optic nerves. It is significant that both Leis<sup>2</sup> and Stargardt,<sup>3</sup> in their excellent anatomic studies dealing with syphilitic atrophy, noted the arachnoidal bands in the optochiasmatic region, but did not attribute to them any particular significance in the genesis of the atrophy of the optic nerves.

#### RESULT OF OPERATIONS

Surgical intervention in cases of syphilitic optic nerve atrophy is being carried out with increasing frequency. Vincent<sup>1a</sup> went so far as to raise the question whether one should not operate in all cases of "tabetic optic nerve atrophy." He summed up the question by saying that it is not possible to give a final answer as to the propriety of such intervention and that the results of more operations must be awaited. Vincent<sup>1a</sup> made these comments in the discussion on a case of syphilitic optic nerve atrophy in which he had removed the thickened chiasmatic arachnoid but the operation was not followed by improvement of vision. In general, the results of this exploratory operation on syphilitic patients with optic nerve atrophy have been conflicting, some observers reporting little, if any, improvement of vision, while others are enthusiastic about the procedure. In Cushing's<sup>12</sup> patient with optic nerve atrophy due to congenital syphilis, the removal of the thick arachnoidal adhesions did not lead to improvement of vision. Dandy<sup>17</sup> performed exploratory operations in 3 cases. In none was there any evidence of adhesive arachnoiditis, and the operative results were neither beneficial nor deleterious. Hausman,<sup>14</sup> on the other hand, observed adhesions around the optic chiasm in all 3 cases in which he operated, and after removal of the adhesions vision improved. The most enthusiastic advocates of the surgical treatment of primary syphilitic optic nerve atrophy have been Vail,<sup>1b</sup> Hausman<sup>1c-e</sup> and Schaub<sup>1f</sup>. They stated that if the operation is performed before it is too late improvement in vision may result. Schaub<sup>1f</sup> observed 10 cases of syphilitic optic nerve atrophy treated surgically. In only 1 of these did the process progress to blindness. The condition in the others remained stationary or showed slight visual improvement. However, the criticism must be made that

17 Dandy, W. E., cited by Moore, J. E., Hahn, R. D., Woods, A. C., and Sloan, L. *The Treatment of Syphilitic Primary Optic Atrophy*, *Am J Syph, Gonorr & Ven Dis* 26: 407, 1942.

in most cases of syphilitic optic nerve atrophy in which operation was performed not enough time had elapsed before the cases were reported to justify convincing conclusions.

Moore and Woods<sup>17</sup> stated the belief that in spite of the negative result in some instances, surgical exploration of the chiasmic area is justified in cases of syphilitic primary atrophy of the optic nerves in which visual failure is progressive in spite of malarial therapy, which at that time was the most efficacious mode of treatment. This was also my advice before the present histopathologic study disproved the theory that syphilitic optochiasmatic arachnoiditis is the underlying cause of optic nerve atrophy. The question arises as to the effect the conclusions of this study will have on the suggestions of such outstanding authorities on syphilitic optic nerve atrophy as Moore and Woods, although they admitted that, in their opinion, the results of operation were not hopeful, to say the least<sup>18</sup>. Or should one listen to the advice of Cushing,<sup>12</sup> who counseled all to strive for the avoidance of futile operations in cases of primary optic atrophy?

The final decision must be left to the physician who is in charge of the patient with syphilitic optic nerve atrophy. That a decision will be difficult is indicated by the favorable reports of surgical intervention by other surgeons. But it must be emphasized that most such cases concern patients with failing vision in the early stages of syphilis. Alpers and Yaskin<sup>19</sup> described a case of neurosyphilis with failing vision in which there was no response to medical treatment. A trans-frontal craniotomy was performed, and the removal of chiasmatic arachnoiditis resulted in complete relief from headache and disturbance of vision. On the other hand, in a similar case of neurosyphilis in the early stages François<sup>20</sup> did not see any visual improvement after operation, but later, with the use of fever therapy and sulfur in oil, vision improved in one eye. The other eye remained blind. In these instances there was also choked disk, which is rare in cases of late neurosyphilis and is practically never present in cases of primary syphilitic optic nerve atrophy. The pathologic process underlying loss of vision, if a choked disk is present, is difficult to ascertain. In some instances papilledema is due to the presence of a gumma, producing generalized intracranial pressure<sup>14</sup>. Or the papilledema may be due to syphilitic retrobulbar neuritis, confined to the most anterior portion of the orbital

18 Moore, J. E., and Woods, A. C. The Pathology and Pathogenesis of Syphilitic Primary Optic Atrophy. A Critical Review, *Am J Syph, Gonorr & Ven Dis* **24** 59, 1940.

19 Alpers, B. J., and Yaskin, J. C. Choked Disc in Syphilis of the Nervous System, *Am J M Sc* **190** 333, 1935.

20 François, J. Arachnoïdite optochiasmatique syphilitique et pyrétotherapie, *Bull et mém Soc franç d'opht* **50** 185, 1937.

portion of the optic nerves<sup>21</sup> If vision improves after exploration of the chiasm, one is justified in attributing the favorable result to the operation. However, one should not forget that cases of spontaneous recovery of vision and subsidence of papilledema in the earlier stages of syphilis have been reported by Wilbrand and Saenger<sup>21</sup> in which the patient received only routine antisyphilitic treatment, or no therapy at all.

### CONCLUSIONS

Recent theories have attributed the cause of primary syphilitic atrophy of the optic nerves to syphilitic optochiasmatic arachnoiditis, and surgical intervention has been recommended. On the basis of a histologic study of 12 cases of syphilitic primary atrophy of the optic nerves, the propriety of surgical intervention is discussed.

In 4 cases of syphilitic atrophy of the optic nerves no arachnoidal adhesions were present at all, and in 2 other cases the slight arachnoidal thickening could be considered as still within normal limits. In the other 50 per cent of cases there was definite syphilitic arachnoiditis in the optochiasmatic region. In these cases the pronounced thickening of the arachnoid, bulging the optic nerves, the chiasm and, at times, the third and other cranial nerves, suggested from the gross appearance alone that the arachnoidal process could be implicated in the atrophy of the optic nerves. Microscopic examination corrected this erroneous impression, revealing that the thickened arachnoid passed harmlessly over the optic nerves and chiasm, leaving no signs of pressure, such as constrictive grooves in the optic nerves.

Primary syphilitic optic nerve atrophy is essentially the result of an inflammatory process in the intracranial portion of the optic nerves and in the chiasm. The inflammation has its origin in a basilar syphilitic meningitis, which in some instances produces an optochiasmatic arachnoiditis and in others leaves the basilar arachnoid grossly unaltered.

Surgical removal of the arachnoidal adhesions will be of little, if any, benefit because the inflammatory process within the optic nerves and chiasm remains unaltered by the operative procedure.

The most efficacious treatment of primary syphilitic optic nerve atrophy at the present time is malarial therapy<sup>5</sup> aided by a course of concomitant and subsequent injections of penicillin with 5,000,000 units in each course.

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21 Wilbrand, H., and Saenger, A. *Die Neurologie des Auges*, Wiesbaden J. F. Bergmann, 1913, vol. 5, p. 246.

# OCULAR INJURY DUE TO SULFUR DIOXIDE

## I Report of Four Cases

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SULFUR dioxide in high concentration in the form of the liquefied gas commonly used in domestic refrigerators is an occasional cause of serious ocular injury. Accidental spraying of liquefied sulfur dioxide into the eyes of persons working on refrigeration machines has in some instances permanently reduced vision to light perception through production of corneal opacification and vascularization. The manner in which sulfur dioxide causes such severe damage is conjectural. In the present report, 4 cases of ocular injury due to sulfur dioxide are described, and in a subsequent report an experimental study will be presented aimed toward an elucidation of the means by which sulfur dioxide causes the damage.

Several previous descriptions of ocular injury due to liquid sulfur dioxide have been presented. A report of an accident involving squirting of liquid sulfur dioxide into the face was given by Kennon<sup>1</sup> (1927), who noted recovery of 20/15 vision following superficial corneal and conjunctival injury. He drew the conclusion that sulfur dioxide is relatively innocuous, but this impression was not confirmed in the experience of Clark,<sup>2</sup> who described 2 cases in which exposure to liquid sulfur dioxide resulted in serious corneal opacification and loss of vision.

Other instances of injury by sulfur dioxide refrigerant, with the outcome varying from complete recovery to dense corneal opacification, were noted, but not described in detail, by Shafer (cited by Clark<sup>2</sup>) and Goldburgh and Gouley.<sup>3</sup> A single instance of injury of the cornea and conjunctiva from liquid sulfur dioxide which was successfully treated with an amniotic membrane graft is included in a series of cases of caustic

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From the Howe Laboratory of Ophthalmology, Harvard Medical School, and the Massachusetts Eye and Ear Infirmary.

1 Kennon, B. R. Report of a Case of Injury to Skin and Eyes by Liquid Sulfur Dioxide, *J Indust Hyg* 9 486-487, 1927.

2 Clark, C. P. Accidental Freezing of the Eye by Sulfur Dioxide, *Am J Ophth* 19 881-884, 1936.

3 Goldburgh, H., and Gouley, B. Sulfur Dioxide Chemical Pneumonia, Report of a Case with Recovery Following Accidental Explosion of a Refrigerator, *Unit Ann Int Med* 18 237, 1943.

burns studied by Sorsby and Symons<sup>4</sup> Inquiry among a number of other ophthalmologists revealed that several had seen patients with ocular injuries from sulfur dioxide Presumably, owing to the occurrence of a considerable number of unreported accidents, the presence of an ocular hazard appears to be generally recognized among persons using liquid sulfur dioxide in the refrigeration, as well as in the petroleum, industry

When only the gaseous form of sulfur dioxide is employed, as in magnesium foundries, ocular reactions are, by contrast, relatively mild This difference is no doubt due to the warning characteristics of the gas, which permit avoidance of excessive exposure Whereas accidental contamination with the liquid occurs with such suddenness as to preclude effective reflex self protection, exposure to the gas produces symptoms which make its presence obvious, and even unbearable, at lower concentrations than those which cause ocular damage The warning symptoms and the concentrations at which they occur have been determined by a number of observers (Ogata,<sup>5</sup> Lehmann,<sup>6</sup> Ronzani<sup>7</sup> and Holmes and others<sup>8</sup>) and are considered to consist of a characteristic pungent smell, appreciable at a concentration of 3 to 5 parts per million of air by volume, irritation of the throat, at a concentration of 8 to 12 parts per million, and coughing, painful breathing and a sensation of burning of the eyes, at a concentration of 20 parts per million On account of these unpleasant symptoms, it is considered that 10 parts of sulfur dioxide per million of air is the maximum concentration tolerable for long exposures and that 50 to 100 parts per million is the maximum for exposures of one-half to one hour However, an appreciable increase in tolerance is noted among persons chronically exposed

Conjunctival inflammation has often been mentioned as a frequent consequence of prolonged exposure to high concentrations (Flurry and Zernik,<sup>9</sup> Kehoe and associates<sup>10</sup> and Humperdinck<sup>11</sup>) and has at times

4 Sorsby, A, and Symons, H M Amniotic Membrane Grafts in Caustic Burns of the Eye, *Brit J Ophth* **30** 337-345, 1946

5 Ogata, M Ueber die Giftigkeit der schwefligen Saure, *Arch f Hyg* **2** 223, 1884

6 Lehmann, K B Experimentelle Studien uber den Einfluss technisch und hygienisch wichtiger Gase und Dampfe auf den Organismus, *Arch f Hyg* **18** 180-191, 1893

7 Ronzani, E Ueber den Einfluss Einatmungen reizender Gase der Industrien auf den Verteidigungskraft des Organismus gegenuber den infektiiven Krankheiten, *Arch f Hyg* **67** 285, 1908

8 Holmes, J A, Franklin, E C, and Gold, R A Report of the Selby Smelter Commission, Bulletin 98, United States Department of Interior, Bureau of Mines, 1915, pp 172-175

9 Flurry, F, and Zernik, F Schadhliche Gase, Dämpfe, Nebel, Rauch- und Staubarten, Berlin, Julius Springer, 1931, p 143

been sufficient to necessitate change of occupation (Lewin and Guillery<sup>12</sup>) However, permanent ocular damage from occupational or accidental exposure to gaseous sulfur dioxide appears to be rare and is apparently unlikely to occur even in acute, nearly lethal exposures to the gas Such conclusions may be drawn from the report of Rostoski and Crecelius<sup>13</sup> on the consequences of exposure of 33 men to sulfur dioxide for eight to forty-five minutes in high enough concentrations to cause the death of 10 and to leave 18 with chronic bronchitis, emphysema and bronchiectasis Although all the men were said to have had severe inflammation of the eyes and oral mucous membrane immediately after the accident, a persistent ocular disturbance ("conjunctival catarrh") was noted in only 1 survivor In other instances of accidental exposure to gaseous sulfur dioxide little attention has been paid to the ocular inflammation, whether acute or chronic (Humperdinck,<sup>11</sup> Wiese,<sup>14</sup> Goldburgh and Gouley<sup>3</sup>)

In contrast to the reports already mentioned is that of Strebel,<sup>15</sup> in which emphasis was placed on the presence of a superficial central punctate keratitis characteristically occurring in the manufacture of viscose and attributed by him to the action of sulfur dioxide As pointed out by Knapp,<sup>16</sup> Strebel was apparently in error as to the cause of the disturbance Sulfur dioxide is not ordinarily employed in the manufacture of viscose, and none of the commoner symptoms of exposure to sulfur dioxide were noted Furthermore, it appears that the condition described by Strebel was identical with that subsequently considered by other investigators to be due to the hydrogen sulfide which is formed in the viscose process (Hortsch,<sup>17</sup> Barthelmy,<sup>18</sup> Rodenacker<sup>19</sup>)

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10 Kehoe, R A , Machle, W F , Kitzmiller, K , and LeBlanc, T J On the Effects of Prolonged Exposure to Sulfur Dioxide, *J Indust Hyg* **14** 159-173, 1932

11 Humperdinck, K Zur Frage der chronischen Einwirkung von Schwefeldioxydgasen, *Arch f Gewerbepath u Gewerbehyg* **10** 4-18, 1940

12 Lewin, L , and Guillery, H Die Wirkungen von Arzneimitteln und Giften auf das Auge, *Handbuch fur die gesamte arztliche Praxis*, Berlin, A Hirschwald, 1905, vol 1 and 2

13 Rostoski, O , and Crecelius Zur Kenntnis der Sulfidgasvergiftungen, *Deutsches Arch f klin Med* **168**.107, 1930

14 Wiese, E Untersuchungen in einer Leichtmetallgiesserei, abstracted, *Zentralbl f Gewerbehyg* **28** 109, 1941

15 Strebel, J Durch SO<sub>2</sub> verursachte Augenschadigungen (spez zentrale punktförmige Viskoseverätzung der Hornhaute) Schutz durch Maskenbrille mit Zinkkohlefilter, *Schweiz med Wchnschr* **53** 560-561, 1923

16 Knapp, P Zur Frage der Keratitis traumatica infolge Einwirkung von Gasen, *Schweiz med Wchnschr* **53**.702, 1923

17 Hortsch, W Schwefelwasserstoff die Ursache der Augenerkrankungen in der Viskose-Kunstseidenindustrie, *Veröffentl a d Geb d Volksgesundhdienst* **47**: 669-734, 1937

## REPORT OF CASES

CASE 1—In August 1941, E. L., a man aged 27, with previously normal eyes and normal health, received a spray of sulfur dioxide and oil in both eyes from the explosion of a refrigerator on which he was working. There was immediate blurring of vision, but little discomfort. His eyes and face were washed with water, but the attention of an ophthalmologist was sought only after four days, when ocular pain and photophobia became considerable. Vision at that time permitted counting of fingers at 8 feet (240 cm) with the right eye and at 5 feet (150 cm) with the left eye. There was gray opacity of both corneas with some conjunctival edema and erosion, especially in the right eye. Despite treatment with a bland ointment and atropine, the photophobia, epiphora and intense conjunctival injection persisted, but vision in the left eye improved to 20/40 in the next four months. Vision in the right eye never improved beyond 20/200 and in four years was reduced to distinguishing light and dark. Loss of vision in the right eye was due to corneal opacity, which in the early stages had appeared diffuse and infiltrative, but after four years was characterized by a dense central plaque, surrounded with a halo of gray infiltration and extensive superficial and deep vascularization. A small central area stained with fluorescein at times. Because of incapacitating discomfort from severe photophobia and a sensation of burning, the cornea of the right eye was covered with a conjunctival flap, giving the patient nearly complete relief for the first time in four and one-half years.

CASE 2—H. B., a man aged 52, in normal health except for his eyes, was seen for the first time ten years after the explosion of a sulfur dioxide refrigerator in his face. His face and eyes had been heavily contaminated with oil and sulfur dioxide, which he could make little attempt to wash off because the accident occurred at some distance from running water. He had immediate serious diminution in vision, which did not improve. Ten years after the accident he could perceive only hand movements at 5 feet with the right eye and at 3 feet (90 cm) with the left eye but had good light projection. Leukomas of both corneas, with superficial vascularization, were present. There was pronounced symblepharon of both eyes, with thick bands of tissue extending from the fornices to the cornea. The appearance at this stage is shown in the figure. An optical iridectomy was done in the left eye several years after the accident. Later, a resection of a portion of the corneal scar in the right eye and transposition of the symblepharon tissue, followed by roentgen irradiation of the vascularized cornea, was of no apparent benefit.

CASE 3—F. K., a man aged 21, and his brother, A. K. (case 4), received a spray of sulfur dioxide and oil in both eyes from a refrigerator on which they were working. Since discomfort was slight, although vision was blurred, efforts at decontamination consisted principally in wiping their faces and eyes. Two hours later there were edema of the lids, blepharospasm and conjunctival edema, with grayness of the corneas, which stained faintly with fluorescein in the area of the palpebral fissures. In addition to injuries of the eyes, both patients received superficial burns of the mucous membranes of the lips, tongue and nose, with temporary loss of sense of taste and smell, as well as some tracheal irritation.

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18 Barthelmy, H. L. Ten Years Experience with Industrial Hygiene in Connection with Manufacture of Viscose Rayon, *J. Indust. Hyg.* **21** 141-151, 1939.

19 Rodenacker, G. Die gewerblichen Gefahren des Schwefelwasserstoffes, *Med. Klin.* **37** 215-217, 1941.

In case 3 the immediate signs were all more prominent in the left eye than in the right. Three days after exposure vision was 20/30 in the right eye and 20/40 in the left eye. There was some superficial opacity of the left cornea, and both corneas stained in part. The conjunctivas were still intensely injected and edematous, with a number of small hemorrhages and pale areas of vascular thrombosis, particularly in the left eye.

By the end of the first week the relatively mild degree of involvement of the right eye was obvious, for by then the cornea was practically normal, and in two or three weeks after injury this eye had entirely regained its normal appearance. On the other hand, the more serious nature of the injury to the left eye was suggested during the first week by the appearance of irregularity of the endothelium, slight stromal edema and some opacification. Increased prominence of the corneal nerves was also noted in this eye and the cornea was definitely anesthetic.

For two to three weeks after injury small areas of the cornea of the left eye stained irregularly, and opacification gradually increased in both the superficial and the deep stroma of the temporal portion. This was soon accompanied with super-



Appearance of the eyes ten years after injury by sulfur dioxide (case 2)

ficial and interstitial vascularization. During the first two months the central and temporal portions of the corneal stroma became heavily vascularized. However, during the third to the fifth month there was appreciable clearing.

At no time did the patient have any real pain, although in the first several weeks there were considerable photophobia and some scratching sensation. Mydriasis was maintained with atropine, and subsequently with scopolamine for four months. During this time there was no elevation of intraocular pressure or evidence of iritis.

CASE 4—A K, a man aged 28, received a spray of sulfur dioxide and oil in his eyes in the same accident as that sustained by his brother (case 3). He experienced the same relatively slight discomfort but had more pronounced immediate blurring of vision. Two hours later there were severe conjunctival edema, blepharospasm and grayness of the corneas, which stained faintly with fluorescein. The lids were edematous but did not appear to be injured. Three days later both corneas were gray with a grossly irregular, lusterless surface, more noticeable in the right eye. Both corneas stained moderately with fluorescein and were completely anesthetic. The conjunctivas were edematous and pale, with thrombosis



of all visible vessels. Vision was reduced to the perception of hand movements in the right eye and to counting fingers at 3 feet in the left eye.

By the end of the first week the dense grayness and irregularity of the anterior surface of the corneas were lost centrally, and vision was considerably improved. However, the stroma of both corneas was still moderately thickened, and the endothelium was gray and irregular. The corneal nerves were abnormally prominent. The conjunctival vessels were still thrombosed, but many small hemorrhages had now appeared, so that the original pallor of the conjunctivas was replaced with a beefy appearance.

During the remainder of the first month the corneas remained fairly clear, although there was persistent staining, more conspicuous in the right eye, and faint laminate opacities could be seen in the stroma, both at the anterior surface and in the central portion. Swelling of the stroma did not progress, and the grayness and irregularity of the endothelium were gradually replaced with a granular appearance. In this period the patient complained of severe photophobia and frontal headaches.

During the second month there were increasing infiltration and opacification of both corneas, with occasional remissions and progressive, dense interstitial vascularization. The anterior surfaces continued to be grossly uneven and to stain irregularly with fluorescein. The photophobia and headache subsided.

In the third month after injury the conjunctivas, which were still severely injected, began to overgrow the corneas, but there appeared to be no tendency to formation of symblepharon.

By the fourth month vision was reduced to perception of hand movements as shadows, owing to corneal opacification and extensive superficial and interstitial vascularization.

During the period described the patient was treated with atropine and then with scopolamine, as was his brother (case 3). At no time was the ocular tension found to be elevated, and no deposits were observed on the posterior surface of the cornea.

#### COMMENT

From the cases described here, it appears that sulfur dioxide causes almost immediate optical alterations in the cornea, most obviously due to changes in the corneal epithelium, which, though opacified, remains adherent to the stroma, as in acid burns. At first there is only minor discomfort, even with serious injury, probably because of damage to the corneal nerves and resultant anesthesia. The patient may become aware of the seriousness of his injury only during the next several hours or days, when there may be further decrease in vision. There are then considerable swelling of the lids and thrombosis of the conjunctival vessels. Loss of the opaque corneal epithelium in several days permits somewhat better vision and in cases of severe injury reveals more clearly the evidences of deeper injury, in the form of stromal edema, opacity of the corneal nerves and a grayness and irregularity of the endothelium. Such deeper changes resemble those produced by the penetrating action of alkalis, and, similarly, the subsequent course may be characterized by the occurrence of stromal infiltrates and interstitial vascularization. In the eyes observed, serious stromal changes of this nature occurred.

with only moderate thickening of the stroma, suggesting that minor impairment of semipermeability of the endothelium may be involved. In these cases there was no problem of either iritis or glaucoma. Except for corneal scarring, conjunctival overgrowth of the cornea or formation of symblepharon appears to be the most frequent complication.

In their principal features, the cases reported here are similar to those of other authors. Thus, the slight degree of injury observed by Kennon<sup>1</sup> in his single case has counterparts in the left eye in case 1 and in the right eye in 3, while the effects described by Clark<sup>2</sup> resemble those observed in some of the other eyes in the present cases. The interpretations of these authors, however, find no support in the present observations. The belief that sulfur dioxide is relatively innocuous is certainly unfounded, while the claim that sulfur dioxide produces its ocular injuries through freezing could not be substantiated without considerable additional information, which is unavailable clinically.

To supply some of the information necessary for evaluation of the mode of action of sulfur dioxide in producing ocular injuries, an experimental investigation has been undertaken and will be reported separately.

#### SUMMARY

Ocular injuries resulting from spraying of liquid sulfur dioxide and oil into both eyes in 4 cases were characterized in most instances by immediate damage to the corneal epithelium, as in acid burns, with underlying stromal and endothelial injury, as in alkali burns. In the cases of mildest injury the outcome was complete recovery, while in the cases of severest damage dense opacification followed corneal infiltration and interstitial vascularization.

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## OCULAR INJURY DUE TO SULFUR DIOXIDE

### II Experimental Study and Comparison with Ocular Effects of Freezing

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THE ACCIDENTAL injuries of the eye produced by liquefied sulfur dioxide which have been reported by myself<sup>1</sup> and others have usually been severer than those produced by other substances with similar moderately acidic properties. To account for the greater toxicity of sulfur dioxide, previous observers have proposed some rather unusual mechanisms based on the physical and chemical peculiarities of the noxious agent. Experiments carried out in this laboratory indicate that a relatively simple mechanism, different from those previously proposed, is responsible in large measure for the peculiar toxicity of sulfur dioxide.

The following two hypotheses have previously been advanced to explain the severity of ocular injury produced by liquid sulfur dioxide. It has been assumed by some investigators that injury of the eye is due to freezing produced by the rapid evaporation of the liquefied gas (Kennon,<sup>2</sup> Clark<sup>3</sup>), while others have assumed that injury is caused by the oxidative formation of sulfuric acid from sulfur dioxide on the moist mucous membrane surfaces (Flurry and Zernik,<sup>4</sup> Rost<sup>5</sup>). That sulfurous acid, which is formed directly on contact of sulfur dioxide with water, could itself be sufficiently injurious to produce the damage observed has not been seriously considered, perhaps because sulfurous acid is a relatively weak acid, similar to phosphoric acid, and might therefore not be expected to cause the serious disturbances observed clinically.

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From the Howe Laboratory of Ophthalmology, Harvard Medical School, and the Massachusetts Eye and Ear Infirmary.

1 Grant, W M. Ocular Injury Due to Sulfur Dioxide. I. Report of Four Cases, *Arch Ophth*, this issue, p 755.

2 Kennon, B R. Report of a Case of Injury to Skin and Eyes by Liquid Sulfur Dioxide, *J Indust Hyg* 9 486-487, 1927.

3 Clark, C P. Accidental Freezing of the Eye by Sulfur Dioxide, *Am J Ophth* 19 881-884, 1936.

4 Flurry, F, and Zernik, F. *Schadliche Gase, Dampfe, Nebel, Rauch und Staubarten*, Berlin, Julius Springer, 1931, p 143.

5 Rost, E, in von Bock, J, and others. *Handbuch der experimentellen Pharmakologie*, Berlin, Julius Springer, 1927, vol 3, pt 1, pp 389-417.

The evidence cited to support the idea that frostbite is an important factor is the indefinite report by Carroll<sup>6</sup> of a case in which partial epithelial denudation of the cornea and temporary conjunctival congestion developed after exposure to a cold wind on two successive days. Similarly, keratitis epithelialis, resolving completely in three days, was reported by Colombo<sup>7</sup> as occurring in an aviator exposed to wind and low temperature for several hours. However, there seems to be little similarity to injury with sulfur dioxide in either case. Furthermore, there appears to be no experimental information on the effects of freezing of the eye which could be used as a basis for comparison.

The evidence that the injury results from oxidation of sulfur dioxide to sulfuric acid is also unsatisfactory. It is based on the fact that the major portion of sulfurous acid or its salts (bisulfite or neutral sulfites) which are ingested or injected can be accounted for in the form of sulfate in the urine (Rost and Franz<sup>8</sup>) and that little sulfite can be found in the circulating blood after the ingestion of large amounts of the sulfite. These observations led to the assumption that the oxidation to sulfate occurred in the lining of the gastrointestinal tract, but it is noteworthy that sulfite introduced directly into the blood stream also disappears rapidly.<sup>8</sup> From such evidence it has been inferred that oxidation of sulfur dioxide similarly occurs on the mucous surfaces of the respiratory system and elsewhere, with production of enough sulfuric acid to account for the lesions produced by exposure to sulfur dioxide. However, the formation of sulfuric acid in significant amounts on mucous membrane surfaces has not been demonstrated directly.

Previous experiments on ocular lesions due to sulfur dioxide have been confined to cursory observations and limited to the effect of exposure of animals to mixtures of the gas and air. Ogata<sup>9</sup> reported clouding of the corneas of rabbits, guinea pigs and mice after exposure for four hours to a concentration of 400 parts per million of air by volume and clouding in 1 guinea pig after exposure for one hour to a concentration of 1,000 parts per million. Weedon and associates<sup>10</sup> mentioned the occurrence of corneal opacification in mice and guinea

6 Carroll, F. Frost Bite of the Cornea, *Am J Ophth* **16**:994, 1933

7 Colombo, G. L. Bilateral Changes in the Corneae Following Exposure to Cold in an Airman, *Brit J Ophth* **5** 553-558, 1921

8 Rost, F., and Franz, F. Vergleichende Untersuchung der pharmakologischen Wirkungen der organische gebundenen schweflichen Säuren und des neutralen Schwefligsauren Natriums II, *Arch d k Gsndtsamte* **43** 187-303, 1912

9 Ogata, M. Ueber die Giftigkeit der schwefligen Säure, *Arch f Hyg* **2** 223-245, 1884

10 Weedon, F., Hartzell, A., and Setterstrom, C. Effects on Animals of Prolonged Exposures to Sulfur Dioxide, *Contrib Boyce Thompson Inst* **10**:281-324, 1939

pigs exposed to concentrations of 110 to 300 parts per million of air for approximately three days, and McNally<sup>11</sup> noted severe conjunctivitis and corneal opacity in guinea pigs killed by exposure to 10,000 parts of sulfur dioxide per million of air for fifteen minutes. No experimental investigation of the effect of exposure to liquid sulfur dioxide has been made.

Because of this lack of information on the possible physical and chemical effects of liquid sulfur dioxide on the eye, and the consequent uncertainty regarding the mechanism of production of the lesions observed clinically, the following experimental investigation and comparison of these effects was undertaken.

#### EXPERIMENTAL INVESTIGATION

*Effect of Freezing*—Owing to the paucity of information on the consequence of brief freezing of the living eye, observations were made on the effect of exposing the rabbit eye to a refrigerant liquid. In order to permit clear differentiation of physical and chemical effects in these experiments, use was made of a chemically inert, relatively nontoxic refrigerant, "freon-12" (dichlorodifluoromethane). This refrigerant has physical properties similar to those of sulfur dioxide but a relatively innocuous chemical nature, as confirmed by the observation that exposure of a rabbit's eye to a rapid stream of the pure gas at room temperature for ninety seconds caused no irritation or injury of the eye apparent grossly, on application of fluorescein or on biomicroscopic examination during the ensuing three days. Liquefied "freon," on the other hand, may be assumed to produce a temperature as low as, or lower than, that produced by sulfur dioxide when permitted to evaporate in contact with the eye, since at atmospheric pressure its boiling point is  $-28^{\circ}\text{C}$ , as compared with that of  $-10^{\circ}\text{C}$  for sulfur dioxide.

Experiments with freezing were first carried out with a mixture of liquefied "freon" and oil, analogous to the mixtures of sulfur dioxide and oil to which the patients were exposed in the accidents previously reported.<sup>1</sup> Each of 2 rabbit eyes was held open by means of a speculum and was subjected at a distance of about 6 inches (15 cm) to the full blast of a spray obtained by opening wide the valve on an inverted tank of the "freon"-oil mixture. The duration of exposure to the spray was approximately one second, which is presumably somewhat longer than a human being would keep his eye open in similar circumstances. The corneas and margins of the lids became white and hard during the spraying, but regained their normal appearance during the next five or ten seconds. Biomicroscopic examination revealed no

<sup>11</sup> McNally, W. The Use of Sulfur Dioxide as a Refrigerant, *Indust Med* 8: 234-238, 1939.

abnormality immediately. During the next few hours there appeared slight vascular congestion and edema of the nictitating membrane and conjunctiva. Moderate edema of the corneal epithelium gradually developed, progressing to denudation of a small central area in twenty-four hours. Within seventy-two hours of the exposure and thereafter the eyes appeared normal, both grossly and microscopically.

Freezing of the eye for a few seconds, such as might conceivably occur in an accidental exposure, thus produced disturbances which were mild and transient. For more prolonged freezing, liquid "freon" was sprayed onto 1 rabbit eye for five seconds and onto another eye for thirty seconds. The corneas of both eyes became immediately opaque, dense white and hard. The nictitating membrane and the lids were solid. In one to two minutes the tissues thawed and the normal transparency of the cornea and appearance of the eyes were completely regained. However, in about five minutes the corneal endothelium of the eye which had been exposed for thirty seconds was seen on biomicroscopic inspection to have become gray with dark round and oval defects. There rapidly followed in this eye shedding of most of the endothelium in sheets, which could be seen settling slowly through the aqueous humor. In the eye exposed for five seconds, gray opacity and numerous defects of the endothelium were apparent in fifteen minutes, but shedding was less extensive. At this time, chemosis of the conjunctiva and injection of the iris were apparent in both eyes, but the corneas did not stain. At thirty to forty-five minutes thickening of the corneas and faint diffuse staining with fluorescein were observed. During the next several hours the corneas became swollen to several times their normal thickness and acquired a translucent, bluish appearance. They continued to take a diffuse stain with fluorescein. The conjunctiva, nictitating membrane and margin of the lids of the eye exposed for thirty seconds underwent a severe reaction, with partial necrosis and considerable purulent discharge. Within ten days the cornea of this eye became opaque, yellow and sloughed. The reactions were considerably milder in the eye exposed for five seconds. This eye showed improvement in ten days and appeared practically normal in six weeks. The cornea was clear except for a small gray patch in the center, where some edema of the stroma and epithelium persisted. There was little increased vascularity of the cornea at the limbus.

*Effect of Sulfur Dioxide Without Freezing*—The effects of sulfur dioxide were next examined under conditions in which there could be no question of freezing. Exposures of rabbits and guinea pigs to mixtures of sulfur dioxide and air at room temperature in a constant flow exposure chamber confirmed the production of keratitis and corneal clouding under conditions of time and concentration similar to those reported by other investigators. The results are given in table 1.

Only by lethal concentrations could severe ocular lesions be produced when the whole animal was exposed. In order to observe the production and subsequent course of severe ocular lesions, it was necessary to expose the eyes only.

Such experiments were performed on rabbits by placing the animal in a well ventilated fume hood while the eye was exposed to a rapid current of gas from a tube held within 1 inch (2.5 cm.) of the cornea. The lids were separated, and the nose of the animal was shielded manually during exposure. An exposure of five seconds to a stream of pure gaseous sulfur dioxide at room temperature was observed to produce corneal injury comparable to that encountered in patients exposed to the liquid sulfur dioxide, and this period of exposure was used as a standard for subsequent investigations of the mechanism of injury. The longer time of exposure required by the gas to produce an injury comparable to that from the liquid may be explained by the fact that while 1 cc. of the liquid contains 1.4 Gm. of sulfur dioxide, 1 cc. of the gas contains only 0.0026 Gm.

This exposure for five seconds caused intense superficial grayness of the cornea, beginning immediately and increasing for one to two

TABLE 1—*Effects of Exposure of Animals to Mixtures of Sulfur Dioxide and Air*

Sulfur Dioxide, P P M *	Exposure Time	Animals Used	Results
145 (120-170)	10 days	2 rabbits	No keratitis, animals appeared moribund
400-490	30 hr	2 rabbits, 3 guinea pigs	All had keratitis, all dead within 72 hr after end of exposure
800-1,000	24 hr	2 rabbits 3 guinea pigs	All had keratitis and corneal opacity, all dead within 24 hr after end of exposure

\* P P M indicates parts of sulfur dioxide per million of air by volume

minutes. Chemosis and injection of the conjunctiva appeared within a few minutes and were soon accompanied with a milky discharge. For several days the cornea was persistently gray, with the opacity occurring predominantly in its superficial layers but extending also in a granular and lamellar fashion throughout the thickened stroma. The epithelium was irregularly thickened and was lost from some areas. These epithelial abnormalities did not appear to be due simply to edema and were not appreciably altered by application of glycerin. In ten days the corneal opacity began to decrease somewhat, while interstitial vascularization extended 2 to 3 mm. from the limbus. The process of slight clearing and increasing vascularization progressed slowly until in six months there were extensive vascularity with the vessels meeting in the center, and moderate opacity.

Histologic sections of rabbit eyes which had received the standard exposure of five seconds to pure gaseous sulfur dioxide were examined at intervals of fifteen minutes to six months after exposure. The pathologic changes observed corresponded in general to those described

by Friedenwald, Hughes and Herrmann<sup>12</sup> as characteristic of severe acid burns. The only possibly distinguishing feature of sulfur dioxide burns was a striking predominance of eosinophils in the corneal infiltrate at all stages. Moreover, there was relatively little iritis in these eyes. As described for the acid burns, the corneal endothelium was not obviously damaged.

*Effect of Hydration Products of Sulfur Dioxide*—Information on the chemical mechanism by which sulfur dioxide may cause the changes observed in the preceding experiment was sought by investigation of some of the chemical transformations which might be involved. It would be expected that sulfur dioxide in moist buffered tissue would primarily be converted into sulfurous acid, acidic bisulfites and neutral sulfites in proportions determined by the effectiveness of buffering, and that there might be differences in the toxicity of these various forms. Furthermore, the possibility of oxidation to a stronger acid was to be considered.

Since it was not feasible to determine the amount of each of these derivatives formed in the cornea on exposure to sulfur dioxide, the total sulfur dioxide in all forms was measured. It was then possible to introduce similar quantities of bisulfite and neutral sulfite alone into other corneas and to compare their toxicities. The rate of disappearance of sulfur dioxide and its derivatives was also measured, and tests were made for the formation of sulfuric acid.

The total quantity of sulfur dioxide present in all forms was measured in rabbit corneas excised immediately after exposure for five seconds to sulfur dioxide gas. Extracts of individual corneas in alcoholic potassium hydroxide solution were made and analyzed by a colorimetric method (Grant<sup>13</sup>). The concentrations of sulfur dioxide found immediately and at intervals after exposure are shown in the chart. The concentrations found in the conjunctiva and the aqueous are given in table 2 for comparison.

It may be observed from these data that the concentration of sulfur dioxide in all forms in the living cornea decreases exponentially with time, with a half-life of approximately fifteen minutes. Furthermore, the rise in concentration of sulfur dioxide in the aqueous humor immediately after exposure suggests that the cornea and conjunctiva are readily permeable to sulfur dioxide.

Qualitative testing of the neutralized corneal extracts by means of barium chloride failed to reveal an increase of sulfate such as might be found if a significant proportion of the sulfur dioxide were oxidized to sulfuric acid.

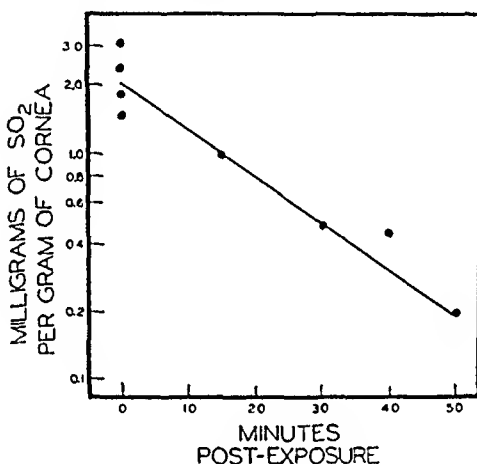
<sup>12</sup> Friedenwald, J. S., Hughes, W. F., and Herrmann, H. Acid Burns of the Eye, *Arch. Ophth.* **35** 98-108 (Feb.) 1946.

<sup>13</sup> Grant, W. M. Colorimetric Determination of Sulfur Dioxide, *Indust. & Engin. Chem. (Anal. ed.)* **19** 345-346, 1947.



Comparative experiments to assess the relative rates of diffusion of sulfur dioxide from cornea into the air or into aqueous bathing fluids were performed by exposing buttons cut from beef corneas to sulfur dioxide gas for five seconds and then measuring the amounts residual after various periods of standing in air, water or a 5 per cent solution of sodium bicarbonate at room temperature. The half-life of the sulfur dioxide in air-bathed corneal buttons was approximately 240 minutes, while in those bathed by water or sodium bicarbonate it was 5 to 10 minutes. Thus, it appears that during the rapid disappearance of sulfur dioxide from the cornea in vivo diffusion into the air must be an insignificant factor.

To determine the toxicity of sulfur dioxide in the form of sulfite, a neutral 1.4 molar solution of sodium sulfite was dropped onto 2 rabbit eyes continuously for thirty minutes. Analysis of 1 cornea showed



Time relation of decrease in concentration of sulfur dioxide in all forms in the corneas of rabbits following acute exposure to the gas

that a concentration was achieved equivalent to 2.15 mg of sulfur dioxide per gram of cornea, equaling the average concentration found immediately after the exposures to the gas. Although this treatment caused intense conjunctival injection and chemosis, loss of epithelium from the center of the cornea and the presence of aqueous flare, no opacity was produced and the eye was apparently normal in two days.

The toxicity of bisulfite was investigated by irrigation of rabbit eyes for thirty minutes with 5.5 molar sodium bisulfite at its natural  $p_H$  of 3.8, producing a concentration in the cornea equivalent to 4.63 mg of sulfur dioxide per gram of cornea. This concentration was somewhat greater than the highest concentration achieved with exposures to the gas. The damage caused by this treatment resembled that resulting from sulfur dioxide itself but was considerably milder than that produced by an exposure for five seconds. There were severe con-

junctival injection and chemosis, with grayness and irregularity of the corneal epithelium and swelling of the stroma. However, the ground glass appearance of the epithelium, which was not altered by glycerin and the translucent opacity of the stroma cleared completely without vascularization in ten days.

By comparison, it appears that sulfur dioxide must exert its injurious effect principally in the form of sulfurous acid, since neither the neutral sulfite nor the bisulfite produced injury of the severity observed in exposures to sulfur dioxide and the formation of sulfuric acid was negligible. The mechanism by which sulfurous acid might produce these injuries was, therefore, next to be investigated.

*Effect of Sulfur Dioxide (or Sulfurous Acid) on Corneal Catalase* — An indication of whether exposures of the cornea to sulfur dioxide may be attended by inactivation of corneal enzymes was sought through

TABLE 2—Concentration of Sulfur Dioxide in Ocular Tissues

Time Following Exposure	Cornea, Micrograms per Gm	Conjunctiva, Micrograms per Gm	Aqueous, Micrograms per Gm
Immediate (30-90 sec.)	1,860	2,250	340
	1,470	2,920	484
	3,170	627	157
	2,410	1,780	39
Average	2,227	1,894	255
15 minutes	978	260	533
30 minutes	465	376	226
40 minutes	455		430
50 minutes	195		81
90 minutes	108	50	25

measurement of the activity of a single enzyme, catalase. The behavior of this enzyme was investigated only to obtain information on the nature of the changes in the cornea, and not to attempt identification of what specific enzymes might be involved in production of injury.

The catalase activity of single minced rabbit corneas was estimated by volumetric determination of the rate of liberation of oxygen from dilute hydrogen peroxide, using a micromodification of the method of Thompson<sup>14</sup>. One eye of each rabbit was exposed to pure sulfur dioxide gas for five seconds in the manner already described, and the other eye was used as an unexposed control. The corneas were excised, and catalase assay was performed immediately after exposure. The rate of liberation of oxygen ranged from 393 to 840 (average 650) cu mm per minute per gram of cornea for 5 normal corneas, whereas with 2 exposed corneas there was no measurable liberation of oxygen in fifteen minutes. These results are considered to show that an exposure

<sup>14</sup> Thompson, R. Simplified Apparatus for Catalase Determination, *Indust & Engin Chem (Anal ed)* **14**:585, 1942.

to sulfur dioxide which will result in serious injury is immediately attended with changes within the cornea sufficiently drastic to cause inhibition of enzymes. However, it cannot be concluded that the injury to the cornea is due to inactivation of catalase alone, for in separate experiments in which corneal catalase was inhibited by means of hydroxylamine no opacification of the cornea resulted.

Comparative experiments to determine the effect of freezing on corneal catalase were carried out on excised cattle eyes. No significant difference was found between the activity of control corneas and that of corneas of eyes frozen with "freon" for either five or thirty seconds.

*Effect of Sulfur Dioxide on Swelling Properties of the Cornea*—For the purpose of determining whether sulfur dioxide may produce, in addition to inhibition of enzymes, a gross alteration in the physical characteristics of the corneal stroma which is not revealed with the usual histologic technic, measurements were made of the turgescence properties of normal and of exposed corneas, employing the technic of Kinsey and Cogan<sup>15</sup>. Excised cattle eyes were used in these experiments, and the swelling of exposed corneal buttons was allowed to take place in running water so that residual acid would be removed. Five pieces of cornea were used for each determination, and the weights were compared after two thousand six hundred minutes was allowed for swelling. Normal corneal buttons increased in weight 550 per cent, while corneal buttons exposed for ten to fifteen seconds to sulfur dioxide gas increased only 134 per cent. In another set of measurements the control corneal buttons increased 470 per cent in weight, while buttons from corneas exposed for five seconds to the gas increased 159 per cent. Thus, a length of exposure such as causes a severe corneal injury produces a significant alteration in the turgescence properties of the stroma.

This inhibition of turgescence was found to be persistent even though on washing in water, the analytic value for sulfur dioxide was reduced to a quantity not significantly different from the blank value for cornea, which corresponded to approximately 0.5 per cent of the immediate post-exposure concentration. Since it has previously been ascertained that essentially complete recoveries of sulfur dioxide are obtained with the method of analysis employed, it appears that the amount of residual or fixed sulfur dioxide which could be associated with the inhibition of turgescence was not greater than approximately 30 micrograms per gram of cornea.

To determine whether sulfur dioxide solution differs notably from other acids in its ability to inhibit corneal swelling, the effect on swelling of exposures to several other acids was compared. Sets of 5 corneal buttons each were exposed by dipping for two minutes in 0.1 molar

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<sup>15</sup> Kinsey, V. E., and Cogan, D. G. The Cornea. III. Hydration Properties of Excised Corneal Pieces, *Arch. Ophth.* 28: 272-284 (Aug.) 1942.

solutions of seventeen different acids, including sulfurous acid, all adjusted to a  $p_H$  of 2.0 with either hydrochloric acid or sodium hydroxide. The extent of swelling in running water for two thousand six hundred minutes was then measured. The results are given in table 3. The differences observed are no doubt dependent to some extent on differences in rate of penetration, and this factor will be further considered later. However, it is apparent from these measurements that sulfur dioxide solution has no outstanding effectiveness over solutions of other acids in impairing corneal turgescence when the acids have direct contact with the corneal stroma.

*Determination of Permeability of the Cornea to Sulfur Dioxide—*

A comparison was made of the permeability of the cornea to sulfur dioxide and to other acidic substances in order to determine whether the toxicity of sulfur dioxide to the eye may be enhanced by any superior properties of penetration. Such a possibility is suggested by the rapid

TABLE 3—*Effect of Exposure to Various Acids on Subsequent Swelling of Cornea in Running Water*

Acid	Corneal Swelling *	Acid	Corneal Swelling
Control	420	Formic	189
Phenol	386	Phosphoric	158
Trichloroacetic	373	Lactic	150
Boric	308	Oxalic	150
Hydrochloric	295	Monochloroacetic	144
Nitric	287	Acetic	143
Sulfuric	225	Malic	133
Sulfurous	225	Sulfosalicylic	120
Nicotinic	196	Propionic	119

\* The corneal swelling is expressed as the final weight in terms of the percentage of the original weight.

penetration of sulfur dioxide into the aqueous humor of exposed rabbit eyes apparent from the measurements of concentration given in table 2. Excised cattle corneas were fastened to the ends of glass tubes in the manner described by Cogan and Kinsey<sup>16</sup> to form a membrane separating fluid in a tube from fluid bathing the outside. Comparisons of the rate of penetration of acids into the cornea were made by covering the epithelial surfaces with 2 cc of sulfurous acid or other acid while periodically determining the  $p_H$  of 2 cc of water bathing the other side of the cornea. The times required for various acids to lower the hydrogen ion concentration on the other side of the cornea to  $p_H$  5 were determined, and after each experiment the integrity of the epithelial barrier of each cornea was checked by estimation of its permeability to fluorescein. In order to facilitate comparison of the acids, they were all used in 0.1 molar concentration and were adjusted with either hydrochloric acid

<sup>16</sup> Cogan, D. G., and Kinsey, V. E. The Cornea. I. Transfer of Water and Sodium Chloride by Osmosis and Diffusion Through the Excised Cornea, *Arch Ophth* **27** 466-476 (March) 1942.

or sodium hydroxide to  $p_H$  1.0 in one set of measurements and to  $p_H$  2.0 in another. The results of these two sets of timing measurements are given in table 4, together with the dissociation constants of the acids employed.

It may be concluded from examination of these data that the cornea has a relatively high permeability to sulfurous acid which cannot be related simply to its dissociation characteristics. This high permeability can be explained, however, by the fact that sulfur dioxide, which in aqueous solution is in equilibrium with sulfurous acid, has considerable lipid solubility to facilitate its transfer through cellular membranes. Measurement of the distribution of sulfur dioxide between water and a typical lipid, tributyrin, showed that sulfur dioxide is, in fact, preferentially soluble in the lipid. Further evidence indicating that penetra-

TABLE 4—Comparison of Rates of Penetration of the Cornea by Various Acids *in Vitro*

Acid	Time of Penetration (Min)		Dissociation Constant
	$p_H$ 1.0	$p_H$ 2.0	
Sulfurous	53	123	$1.7 \times 10^{-2}$
Trichloroacetic	102	>400	$2.0 \times 10^{-1}$
Monochloroacetic	129	165	$1.4 \times 10^{-3}$
Formic	155	115	$1.76 \times 10^{-4}$
Phosphoric	157	360	$1.1 \times 10^{-2}$
Hydrochloric	157	>400	
Propionic	162	180	$1.4 \times 10^{-5}$
Acetic	180	>400	$1.75 \times 10^{-5}$
Malic	280	>400	$1.5 \times 10^{-2}$
Sulfuric	300	>400	
Sulfosalicylic		>400	
Nitric		>400	
Lactic		>400	$1.35 \times 10^{-4}$

tion of sulfurous acid is effected through a lipid-soluble phase was obtained in examination of the penetration of "latex" membranes, which unreported experiments by Dr. D. G. Cogan have shown to resemble the cornea in being most readily permeable to substances having a definite lipid-soluble phase. Sulfurous acid was found to pass through a "latex" membrane many times faster than phosphorus acid at a comparable concentration and hydrogen ion concentration.

#### COMMENT AND CONCLUSIONS

Observations made in this study on the effect of freezing and of high concentrations of sulfur dioxide at room temperature leave little doubt that it is the chemical properties of liquid sulfur dioxide which are primarily responsible for corneal injury.

The injurious action of solutions of sulfur dioxide on tissue other than the eye has been known since Pfeiffer<sup>17</sup> (1890) described the

17 Pfeiffer, L. Zur Kenntniss der giftigen Wirkung der Schwefligen Saure und ihrer Salze, Arch f exper Path u Pharmacol 27 261-296, 1890

production of protein coagulation, interference with blood supply and necrosis by the substance. The irritant effect and bactericidal action of sulfur dioxide have been noted in numerous subsequent reports. That sulfur dioxide exerts its toxicity principally in the form of sulfurous acid, as concluded in the present experiments on the eye, was previously indicated by Jacoby and Walbaum<sup>18</sup> in a consideration of gastric irritation and was clearly demonstrated by Rahn and Conn<sup>19</sup> in a study on yeast. The conclusion that sulfur dioxide produces an "acid burn" in the eye is supported by the similarity of the histologic changes to those of other acid burns.

When an explanation is sought for the greater toxicity of sulfurous acid than of similar acidic substances, it is observed that sulfurous acid does not have outstanding protein-denaturing properties as compared with other acids, and that, although it does inhibit enzymes, it may do so merely by lowering the  $p_H$ , as claimed by Pfeiffer<sup>17</sup>. In fact, the toxicity of sulfurous acid is particularly notable only where cellular structures are concerned, as in the cornea. According to the foregoing experiments, the peculiar susceptibility of cells to sulfurous acid may be explained by the ready penetration of sulfur dioxide through cell membranes, due to its considerable lipid solubility. Thus it appears that the severity of injury with liquid sulfur dioxide is in large part due to the easy penetration of a high concentration of sulfur dioxide through the semipermeable cellular barriers of the cornea, giving access to vital structural and enzyme proteins, which it denatures.

What specific reactions of sulfur dioxide are involved in its devitalizing action are undetermined, but it does seem possible to conclude, by comparison of the relative rates and  $p_H$  optima, that its reactions with disulfide linkages (Elswoith and Phillips<sup>20</sup>), thiamine (Williams and associates,<sup>21</sup> 1935) or with aldehydes are probably not the basis of its injurious effect.

#### SUMMARY

Freezing of the anterior portion of the living rabbit eye for several seconds produces mild and transient disturbance, while freezing for thirty to ninety seconds causes loss of the endothelium with consequent

18 Jacoby, C, and Walbaum, H. Zur Bestimmung der Grenze der Gesundheitsschädlichkeit der schwefligen Saure in Nahrungsmitteln, Arch f exper Path u Pharmacol **54** 421-438, 1906

19 Rahn, O, and Conn, J E. Effect of Increase in Acidity on Antiseptic Efficiency, Indust & Engin Chem **36**:185-187, 1944

20 Elsworth, F F, and Phillips, H. The Action of Sulfites on the Cystine Disulfide Linkages in Wool. II The Influence of Temperature, Time and Concentration on the Reaction, Biochem J **35**:135-143, 1941

21 Williams, R R, Waterman, R E, Keresztesy, J C, and Buchman, E R. Studies of Crystalline Vitamin B. III Cleavage of Vitamin with Sulfite, J Am. Chem Soc **57**:536-537, 1935

edema of the stroma and epithelium, changes unlike those produced in accidental ocular injury with liquid sulfur dioxide

Lesions similar to those caused by liquid sulfur dioxide can be produced by several seconds' exposure to the pure gas at room temperature, a condition in which there is no question of freezing

The concentration of sulfur dioxide in all forms in the rabbit cornea was measured at intervals after exposure and was found to decrease exponentially, with a half-life of approximately 15 minutes

Introduction of neutral sulfite or bisulfite into the rabbit cornea in concentrations comparable to the total sulfur dioxide concentration of gas-exposed corneas does not produce comparably severe injury, and it is concluded that sulfur dioxide exerts its toxic effect principally in the form of sulfurous acid. No significant production of sulfuric acid was detected

Sulfur dioxide impairs the turgescence properties of the corneal stroma, as well as inactivates corneal catalase

The epithelium and stroma of the cornea have a relatively high permeability to sulfur dioxide, a property which is related to the lipid solubility of sulfur dioxide

It is concluded that the production of severe ocular injury by liquid sulfur dioxide is not due to freezing or to the formation of sulfuric acid, as has formerly been postulated, but is the result of its ready penetration of the corneal epithelium in high concentrations and its action principally as sulfurous acid, in denaturing corneal proteins including enzymes

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# CHRONIC TEARING CURED BY REESTABLISHMENT OF NORMAL TEAR CONDUCTION PASSAGES

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CHRONIC tearing of the eye is usually due to abnormality of the tear conduction passages. These passages consist of (1) the eyelids, (2) the puncta and canaliculi, and (3) the tear sac, its prolongation downward into the nasolacrimal duct, and that portion of the nose into which the nasolacrimal duct drains.

Chronic irritation arising from refractive errors and muscular imbalance occasionally causes chronic tearing. Psychic, glandular or reflex factors are infrequently involved. In cases of the latter type, a drop of an innocuous colored solution e. g., 1 per cent fluorescein sodium, placed in each eye will be quickly transmitted into the nose. The comparative speed with which each eye so clears itself measures the efficiency of the tear-conducting apparatus of each eye. The presence, as well as the concentration, of the colored solution can be gaged by blowing each side of the nose separately into a paper tissue. A more efficient method is to seek for the colored solution with the aid of a cotton-tipped probe placed under the inferior turbinate bone, where the nasolacrimal duct empties. Holmes<sup>1</sup> found this opening to be about 6 mm. behind the anterior attached border of the inferior turbinate bone.

## EYELIDS

Slight degrees of weakness of the facial muscles should first be looked for. The muscular tone and the lines of expression of one side of the face are compared with those on the other. One should test the power of grimacing, of puckering the lips and of resisting the pulling apart of the tightly closed eyelids. Various degrees of weakness of the facial muscles reduce the power of the winking reflex, the motive power of tear conduction. When such muscular weakness is pronounced, a pool of tears accumulates behind the relaxed lower lid until it spills over onto the face. In such cases the tear sac can readily be irrigated into the nose.

<sup>1</sup> Holmes, C. R. Exurpation of the Lacrymal Gland in Epiphora, *Arch Ophth* 48 323-333 (July) 1919.



To reduce the incidence, and severity of chronic tearing arising from weakness or paralysis of the facial muscles, adequate and prompt treatment is necessary. The weakness of the facial muscles resulting from peripheral nerve palsy will be discussed first. Then the involvement of the facial muscles which forms a part of a hemiplegia will be considered.

*Facial Paralysis of Peripheral Origin*—Proper support of the weakened muscles is essential. This prevents the affected muscles from being overstretched by the sound muscles of the opposite side, with consequent facial disfigurement as well as chronic tearing. This support is given by the early application of two strips of adhesive tape firmly attached to the cheek of the nonparalyzed side, one at the level of the upper, the other at the level of the lower, lip. Thence they are carried across the paralyzed side, to which petrolatum has previously been applied to prevent the adhesive tape from sticking, and the ends are securely fastened to the mastoid process of the paralyzed side. Ectropion is prevented by supporting the paralyzed orbicularis oculi with a sling composed of two narrow strips of adhesive tape. These are fastened to the skin at each end of the eyebrow. Thence they are carried downward and cross each other directly below the middle of the lower lid. Gentle massage is given without removal of the strapping. Soiled adhesive tape may be covered with new strips. Vitamin therapy is prescribed. After one week, exercise of the paralyzed muscles before a mirror is recommended. The strapping is left in place until evidence of return of satisfactory muscular power is obtained. This may require two to twelve weeks. Weak faradic current is used during the third week to increase the tone of the paralyzed muscles. The current used is that needed barely to cause contraction when applied to the normal muscles of the other side of the face. The eye is protected with colored glasses furnished with side pieces.

If after persistent trial such treatment proves of little avail, nerve grafting is advised. As in cases of injury to the facial nerve occasionally occurring with mastoidectomy, grafting the peripheral portion of the damaged nerve to the hypoglossal nerve reinnervates the facial muscles, thus reducing tearing. Nerve grafts which successfully bridge the damaged portion of the facial nerve accomplish the same result. If the affected muscles have undergone too much degeneration, plastic repair with fascia lata slings may be of service.

If the tearing should continue because the lower lid remains slightly relaxed after spontaneous regeneration or after grafting of the facial nerve or use of fascia lata slings, the lid requires tightening to bring it in close relation to the globe. This can be accomplished by the scarring

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2 Pickerill, H. P., and Pickerill, C. M. Early Treatment of Bell's Palsy, *Brit. M. J.* 2: 457-459 (Oct. 6) 1945.

that follows several electrocoagulating acupuncture along the lower margin of the lid. With topical anesthesia applied to the lower lid, six acupuncture, spaced 4 mm apart, near the margin of the lid are made with a fine electrode. The current should be strong enough to penetrate the conjunctiva and the tarsus, but not the skin. If more pronounced relaxation of the eyelid has resulted in ectropion, plastic repair is indicated.

*Facial Paralysis of Central Origin*—The facial paralysis of central origin forms a part of hemiplegia. When the emergency has passed and the patient begins to convalesce is the time that the facial as well as other affected muscles should be cared for, as outlined for cases of peripheral injury to the facial nerve.

At times after spontaneous recovery from facial paralysis, lacrimation during eating, the so-called crocodile tears, may develop. Spiller<sup>3</sup> suggested that the phenomenon was due to regeneration of nerve fibers which are misdirected, and so fail to connect with the muscles previously supplied. Ford<sup>4</sup> outlined the possible pathway which these fibers assume. Gottersfeld and Leavitt<sup>5</sup> anesthetized such misdirected regenerating nerve fibers by cocaineization of the sphenopalatine ganglion. A cotton-tipped probe covered with cocaine paste is held for a few minutes just behind the posterior tip of the middle turbinate bone of the affected side. If this procedure proves effective in temporarily stopping the epiphora, 2 per cent procaine hydrochloride, followed by absolute alcohol injected by way of the posterior palatine foramen, will give more lasting relief. Reinjection is recommended should symptoms recur.

Injury to the lid margin may result in formation of a notch through which tears flow onto the face. Such a notch should be repaired by plastic operation. If such an injury is traumatic or occurs after the removal of a chalazion near the intermarginal space,<sup>6</sup> as it does occasionally, the edges of the lacerated lid margin should be accurately sewed together without delay.

Eversion of the lower lid which permits tears to overflow onto the face may be caused by cicatrix following trauma. Thorough and persistent massage may bring relief. Otherwise, a plastic operation will correct the eversion and the tearing. Chronic blepharitis with extensive

3 Spiller, W. G. Contracture Occurring in Partial Recovery from Paralysis of the Facial Nerve and Other Nerves, *Arch Neurol & Psychiat* **1** 564-566 (May) 1919.

4 Ford, F. R. Paroxysmal Lacrimation During Eating as a Sequel of Facial Palsy, *Arch Neurol & Psychiat* **29** 1279-1288 (June) 1933.

5 Gottersfeld, B. H., and Leavitt, F. H. Crocodile Tears Treated by Injection of the Sphenopalatine Ganglion, *Arch Neurol & Psychiat* **47** 314-315 (Feb) 1942.

6 MacMillan, J. A. Prevention and Treatment of Lacrimation, *Canad M A J* **44**:284-288 (March) 1941.

conjunctival hypertrophy or any tumor originating on the conjunctival surface of the lid may produce mechanical ectropion. The use of a 2 per cent solution of silver nitrate, as well as electrocoagulation, will prove of value here. In the aged, relaxation of the muscles of the lower lid is a frequent cause of chronic tearing. A bandage worn at night to support the relaxed muscles is of advantage. Persistent, firm but gentle massage may replace the everted punctum, so that it contacts the lacus lacrimalis. When this method is not successful, the relaxed lower lid, as well as the punctum, can be drawn backward to bring it in close relation to the globe. This is done, as described before, by the scarring which follows several shallow electrocoagulating punctures of the conjunctiva just posterior to the margin of the lid. Severe eversion should be reduced by plastic excision of the redundant tissue. Tumors and other lesions involving the margin of the eyelid should be removed and the defect caused thereby repaired by sliding a graft from the temple.

To emphasize the importance of looking for slight weakness of the facial muscles as an etiologic factor in chronic tearing, I report the case of C. H. S., a man aged 66, who was referred by Dr. Bernard Samuels in January 1943. His right eye had been tearing for more than five years. The past history was irrelevant except for attacks of hay fever. At the first examination, a drop of 1 per cent fluorescein sodium placed in the left eye was quickly transmitted into the nose, but none of the dye was transmitted in the right eye. The right tear sac was readily irrigated into the nose, small amount of mucus stained with fluorescein being washed out. Weakness of the right side of the face was detected. The patient was advised to massage the weakened muscles in an upward direction several times a day. Since tearing continued after several weeks, the right punctum was slit slightly backwards. The condition remaining the same for some time, I tightened the moderately relaxed right lower lid to bring it into close relation to the globe, by means of six electrocoagulating acupunctures, as described. At the next visit fluorescein was transmitted from the right eye into the nose for the first time. Four weeks after the acupunctures were made the right lower lid had tightened and was in firmer contact with the eyeball than was the lower lid of the left eye. Chronic tearing had ceased. Fluorescein was now transmitted from the right eye into the nose more rapidly than from the left. The patient was informed that it might be necessary to repeat this treatment if tearing should reappear. A letter six months later informed me that he had remained cured of his chronic tearing.

#### PUNCTA AND CANALICULI

*Puncta*—The puncta may be closed, blocked or abnormally placed so that they do not contact the lake of tears at the inner canthus. They may be closed congenitally or by formation of scar tissue. They may be blocked by a foreign body, such as an eyelash or, occasionally, a fungous concretion. More commonly they are blocked by chronic swelling, which usually involves the canaliculi as well. An imperforate punctum,

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7 Reese, A. B. Partial Resection of the Lid and Plastic Repair for Epithelioma and Other Lesions Involving Margin of the Lid, *Arch. Ophth.* **32** 173-178 (Sept.) 1944.

whether congenital or the result of scarring following injury (mechanical, bacterial, chemical or thermal), should be opened. This can be done with the use of local anesthesia by perforating the closure with a sharp needle while stretching the lower lid laterally for counterpressure to the penetrating needle, as well as to straighten the bend of the canaliculus into which the needle is directed. A no. 2 probe can then be passed into the lower canaliculus. An indwelling horsehair should be kept in place until epithelization is complete.

If the punctum is blocked with a foreign body, this should be removed. The treatment of a punctum blocked by chronic swelling is discussed later in connection with similarly blocked canaliculi, with which they usually coexist.

The lower punctum may be abnormally placed. It may face away from the globe, thus failing to come into contact with the tears. To replace a slightly everted punctum, the patient daily should firmly, but gently, massage the lower lid upward. If after a trial, this proves unsuccessful, several light electrocoagulating acupuncture points just posterior to the base of the punctum will draw the punctum toward the eyeball when cicatrization is complete.

A more strongly everted punctum may be associated with relaxation of the musculature of the lower lid. Here the relaxed muscles should be tightened, so as to bring the lower lid in close relation to the globe. This is readily accomplished with several electrocoagulating acupuncture points placed close to the margin of the lower lid, as previously described under treatment of paresis of the lid. The contraction of the scars, so produced, tightens the lower lid and simultaneously corrects the position of the strongly everted punctum. Merely slitting such a punctum backward to contact the lacus lacrimalis will not necessarily cure the tearing. This is illustrated in the case previously cited (C. H. S.).

The punctum should be slit backward only as a last resort, and then minimally if the lower lid shows no paresis. If such an incision of the punctum should involve much of the length of the canaliculus, the wide-open gutter thus formed fails to pick up the tears because the capillary action of the punctum is destroyed. When the edges of the cut canaliculus lie close together, repeated cauterizations followed by probing may repair it.<sup>8</sup> Beginning at the inner angle, one should cauterize 1 to 2 mm and then probe with a no. 1 probe. This procedure is repeated at subsequent sittings until the cut canaliculus is repaired. If the lips of the slit canaliculus are farther apart, a plastic operation may bring the freshened cut edges together.<sup>9</sup> This is followed by probing with a no. 1 probe and the use of an indwelling horsehair, to maintain patency.

<sup>8</sup> Spaeth, E. *The Principles and Practice of Ophthalmic Surgery*, Philadelphia, Lea & Febiger, 1941, p. 96.

<sup>9</sup> Sattler, C. H. *Haarnaht geschlitzter Tranenkanalchen*, *Ztschr. f. Augenh.* 64: 352 (April) 1928.

If the lower punctum is found to be unusually placed, as in some cases of congenital closure, an indwelling stitch of woman's hair, fixed on a nontraumatic needle, taken through the misplaced punctum and emerging at a point just touching the lake of tears, will form a properly functioning new punctum when epithelization is complete. Comparison with the punctum of the other eye, if normal, will aid in the proper placement of the newly formed punctum.

*Scarred Canaliculi*—Canaliculi may be closed by scar tissue or blocked by a foreign body or as a result of chronic swelling. If the canaliculus is closed by scar tissue, a sharp needle can be employed, with use of topical anesthesia, to perforate it. The lower lid is pulled away from the direction of the needle during the perforating. If the canaliculus is scarred in its medial portion, the point of the needle should be pushed until it comes into contact with the bony lacrimal fossa. If the punctum as well as the canaliculus is closed by scar, the point for starting the perforation into the tear sac should be slightly closer to the globe than the original punctum. Comparison with the position of the punctum of the normal eye aids in correct selection of the proper point. A probe can then be carefully passed into the tear sac and thence directed downward into the nasolacrimal duct to feel for possible additional obstruction. Patency is maintained by an indwelling horsehair until epithelization is complete. If for any reason the horsehair is removed too soon or if bleeding follows subsequent probing, the horsehair should be reinserted.

Three cases illustrating varying degrees of scarring of the lower canaliculus are described.

The first case is that of Mrs. A. K., aged 52, seen in October 1944. Her right eye had teared for six months. A solution of fluorescein was not transmitted from the right eye into the nose, and irrigation was not possible. With a no. 4 probe a scar was palpable at the medial end of the lower canaliculus of the right eye. This was penetrated, thus allowing free irrigation into the nose. A horsehair was inserted and kept in place for two weeks. A letter from the patient six months later stated that her right eye no longer teared.

The second case is that of Mrs. R. D., aged 53, seen in March 1943, who had tearing of the left eye over four years. The lower canaliculus of the left eye was closed by scar at its medial half. The upper canaliculus allowed irrigation into the nose with difficulty. The upper canaliculus of the left eye was dilated at the second visit, and irrigation into the nose was then easily accomplished. As the patient still complained of tearing, a needle was inserted into the lower canaliculus, penetrating the scar tissue until the bony fossa was palpated. A no. 2 probe could be passed into the tear sac and thence into the nasolacrimal duct. A 27 gage vitallium wire was inserted through the opened lower canaliculus. One end of the wire was formed into a loop to prevent injury to the eye. It was necessary to remove this wire in twenty-four hours because of irritation. Two days later, when the irritation had subsided, a horsehair was inserted into the canaliculus and through the punctured scar after dilation with a no. 3 probe. This horsehair was comfortably retained for two weeks. When the hair was removed, fluorescein was transmitted from the

left eye into the nose. The patient was seen eight months later, at which time fluorescein was transmitted normally into the nose from the left eye.

The third case is that of a man with a completely scarred punctum and canaliculus. M. M., a man aged 79, seen in June 1942, was referred by Dr. A. Kanoff. The patient had had tearing of the left eye for many years and had been treated with repeated probings. The left lower punctum could not be found. The left upper punctum was dilated, permitting irrigation into the nose. As in case 2, the upper canaliculus was patent, yet the passage was not sufficient to prevent tearing. I decided to form a new lower canaliculus. A point was selected on the left lower lid analogous to the position of the lower punctum of the right eye, but slightly closer to the globe. So, with the point of a sharp needle placed at this site, and exerting counterpressure by drawing the lower lid away from the direction of puncture, the needle was passed into the left tear sac until the bony lacrimal fossa was palpated. A thin wire, with the end formed into a loop to avoid injury to the eye, was kept in this puncture for six days. It had to be removed because of its annoyance to the patient, although he was most cooperative. After allowance of three days for the irritation caused by the wire to subside, the puncture wound was probed with no. 1, 2 and 3 probes, and a horsehair was inserted into the newly formed canaliculus. On his next visit, one week later, a drop of fluorescein placed in the left eye appeared in the nose for the first time. Because of the apparent favorable outcome and the presence of coincidental acute rhinitis, the horsehair was removed. Removal proved to have been too soon, for in the following week, when the left canaliculus was probed, there was slight bleeding. The horsehair was therefore replaced. A week later, the hair was removed from the newly formed left lower canaliculus, and irrigation into the nose was easily carried out. On five subsequent visits, the last being October 9, a drop of dye in the left eye quickly appeared in the nose.

*Blocked Canaliculi*—Infrequently the canaliculi may be blocked by a foreign body, such as an eyelash or a firm, nontender lump, which on examination and culture may prove to be a fungous concretion.<sup>10</sup> In case of the latter the punctum is often reddened, elevated and bathed in a small amount of mucus. Rarely is the upper canaliculus so involved. A very small spoon can be used to remove the small particles, resembling grains of sand.

Rarely does such a fungus find its way into the tear sac. Morax<sup>11</sup> reported a case in which the fungus set up a purulent inflammation, which pointed at the third upper molar tooth. Incision and drainage and the use of potassium iodide sufficed to effect a cure.

When the canaliculi are blocked by chronic swelling, the tear sac and nasolacrimal duct are usually similarly blocked, often with the production of secretions, which become infected. The slitlike outlet of the nasolacrimal duct into the nose is surrounded with cavernous tissue,

<sup>10</sup> Brinkerhoff, A. J. Actinomycosis of the Inferior Lacrimal Canaliculus, *Am J Ophth* **25** 978-981 (Aug.) 1942. Turner, N. H. Dacryolithiasis with Stricture of the Lacrimal Ducts, *Virginia M. Monthly* **69** 151-152 (March) 1942.

<sup>11</sup> Morax, V. Sporotrichoses primitive du sac lacrymal, *Ann d'ocul* **144**. 49-53 (Jan.) 1911.

which readily swells in response to an irritating condition, such as chronic rhinitis, sinusitis, spurs or deflections of the nasal septum, nasal polyps, cysts, tumors, scars, an inferior turbinate bone tightly placed against the lateral nasal wall or an allergic irritant. Such irritation obtaining for a long enough period causes the mucous membrane in the area to become so hypertrophic as to shut off proper drainage from the nasolacrimal duct, with resultant tearing.

Such causes of irritation should be removed. When little or no benefit follows proper treatment, Wetzel<sup>12</sup> stresses the importance of tests for syphilis as the cause of the dacryocystitis. Other causes of epiphora often misdiagnosed because of their rarity are early neoplasms,<sup>13</sup> fungous concretions in the tear sac, meningocele, mucocele of the frontal sinus<sup>14</sup> with a fistula at the inner canthus, and ethmoidal mucocele<sup>15</sup> present at the inner canthus. The last-mentioned lesion may be mistaken for an osteoma of the orbit or for a dilated tear sac. It can be differentiated from a dilated tear sac by the fact that it is not tender or elastic to touch and that no fluid can be expressed from it on pressure.

Allergic irritants, which cause sneezing as well as tearing, should be tested for and the allergic condition treated by specific desensitization. If such a regimen should prove ineffective for allergic patients, Negus<sup>16</sup> recommended zinc ionization. In such circumstances, I have found that the electrocoagulating current applied under the mucosa of the inferior turbinate bone is far more effective. As the state of the nasal mucous membrane improves so does that of the conjunctiva, and the tearing ceases.

Incidentally, French workers,<sup>17</sup> as well as the Hilgartners<sup>18</sup> in this country, have used ionization with copper and other metal probes passed into the nasolacrimal duct for the treatment of epiphora. After many

12 Wetzel, J. O. Dacryocystitis. Part Played by Syphilis in Its Etiology, *Am J Ophth* **28** 511-516 (May) 1945.

13 Spratt, C. N. Primary Carcinoma of the Lacrimal Sac, *Arch Ophth* **18** 267-273 (Aug) 1937. Penruan, G. G., and Wolff, E. Primary Tumors of the Lacrimal Sac, *Lancet* **1** 1325-1328 (June 11) 1938.

14 Cohen, C., and Reinking, F. Beitrage zur Klinik der orbitalen Komplikationen bei Erkrankungen der Nebenhohlen der Nase, *Beitr z Augenh* **78** 1-76 (Feb) 1911.

15 Henderson, E. E. The Relation of the Lacrymal Fossa to the Ethmoidal Cells, *Ophth Rev* **30** 352, 1911. McMillan, A. L. A Case of Ethmoidal Mucocele, *ibid* **30** 15, 1911.

16 Negus, V. E. The Relation of Ophthalmology and Rhinology, *Brit J Ophth* **27** 554-557 (Dec) 1943.

17 von Triepier, T., Gorecki, and Lagrange, cited by Fleischer, B., in *Elschnig, A. Handbuch der Augenheilkunde*, Berlin, Julius Springer, 1922, vol 2, p 1532.

18 Hilgartner, H. L., Jr., and Hilgartner, H. L. Use of Copper Ionization in Treatment of Chronic Stenosis of the Lacrimal Duct, *Am J Ophth* **18** 54 (Jan) 1935.

attempts with this modality so applied, I have abandoned it as of too little value. As will be described later, such treatment in the nasolacrimal duct is applied to an effect, not to its cause, which lies in the nasal air sinuses.

Although chronic tearing due to a reflex neurosis from the nose is not included in the category of chronic lacrimation discussed in this paper, it is of interest to note that Negus<sup>16</sup> applied cocaine paste to the sphenopalatine ganglion, behind the posterior tip of the middle turbinate bone. If this stops the tearing temporarily, procaine hydrochloride followed by alcohol can be injected through the posterior palatine canal into the ganglion for more prolonged cessation of tearing.

The mucous membrane walls of the tear sac normally lie in contact when the eye is at rest. This membrane continues downward, forming the lining and the valves of the nasolacrimal duct. Rich venous plexuses underlie this lining membrane, which gradually assumes the characteristics of nasal mucosa as it approaches the nasal cavity. This nasolacrimal membrane shares in the degree of atrophy or hypertrophy<sup>19</sup> of the nasal mucosa. Inflammation of the nasal mucosa around the outlet of the duct blocks it and causes similar inflammatory changes in the contiguous nasal duct and tear sac. Palpation of the tear sac and comparison with the sac on the opposite side reflect accurately the condition of the nasal mucous membrane. Since most of this tissue is contained within a bony canal, the inflammatory swelling readily obliterates the lumen. Probing<sup>20</sup> of the nasal duct in such cases is of little value and may cause trauma which may result in stricture. A stagnant fluid with mucus, and often pus, accumulates in the sac, forcing apart its walls.

Whitnall<sup>21</sup> reported that in 54 per cent of the 100 European skulls he examined the anterior ethmoidal cells extended as far as the anterior margin of the lacrimal groove. Pus arising from suppurative ethmoiditis may spread through the thin lacrimal bone into the lacrimal groove, pointing externally at the inner canthus. A subacute or chronic inflammatory condition of the anterior ethmoidal cells may similarly extend through the lacrimal bone, producing local periostitis<sup>14</sup> of the lacrimal groove, with swelling at the inner canthus and of the eyelids, so blocking the sac, the canaliculi and the puncta. Moreover, the close anastomosis existing between the venous and the lymphatic plexuses of the

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19 Whitnall, S. E. *Anatomy of the Human Orbit and Accessory Organs of Vision*, London, Oxford University Press, 1932, p. 244.

20 Tooke, F. T. Extirpation of Chronically Inflamed Tear Sacs, *Montreal M. J.* **35** 336-341 (May) 1906. Worth, in discussion on Pollock, W. B. T. The Treatment of Chronic Dacryocystitis, *Lancet* **2**:455 (Aug. 12) 1911. Fergus, E. F. Treatment of Lacrymal Suppurative Disease, *Ophth. Rev.* **30** 231-239, 1911.

21 Whitnall, S. E. The Relations of the Lacrimal Fossa to the Ethmoidal Cells, *Ophth. Rev.* **30** 321-325, 1911.



ethmoid and maxillary sinuses and the mucous membrane lining of the lacrimal drainage apparatus would appear to render the latter susceptible to inflammatory lesions of these sinuses

In cases of canaliculi blocked by swelling, usually associated with similar blockage of the nasolacrimal duct, conservative treatment should be begun early. The earlier it is begun, the better the prognosis. The puncta and canaliculi are dilated, followed with repeated irrigations of the tear sac with astringent, antiseptic solutions containing added epinephrine hydrochloride and/or ephedrine sulfate. Sulfonamide compounds, antibiotic solutions or similar agents, and other substances dissolved or suspended in fats, oils and waxes may be instilled into the tear sac for longer action. Such treatment was given at weekly intervals in the office in conjunction with displacement therapy for the concomitant chronic nasal sinusitis. For home treatment, the patient was instructed how to empty the tear sac and how to massage it lightly twice daily. While he is in the recumbent position, he instils a drop of an astringent, antiseptic solution into the eye, both before and after emptying the sac. While he is in this position, the head is turned with the affected side down and held lower than the rest of the body while a few drops of a nasal vasoconstrictor are instilled into each nostril.

In more resistant cases the application of 5 per cent silver nitrate around the nasal orifice with retrograde passage into the nasolacrimal duct is useful. The tip of a nasal applicator is tightly wound with a small piece of absorbent cotton, and the end is so bent at a right angle that it will reach as high up into the duct as possible. As stated previously, in 50 specimens, Holmes<sup>1</sup> found that the orifice of the nasolacrimal duct was at an average distance of 6 mm behind the anterior attached margin of the inferior turbinate bone. If the anterior end of the inferior turbinate bone is tightly placed against the lateral nasal wall it should be fractured toward the midline, with the use of local anesthesia. Chronic swelling and moderate hypertrophy of the mucous membrane may be reduced by injecting sclerosing solutions<sup>22</sup> under the mucosa. I prefer the use of the better controlled electrocoagulating current, which can deal adequately, in addition, with the greatly hypertrophied mucous membrane, polyps, scars and other tumors.

Because chronic tearing caused by blockage due to swelling in the puncta and canaliculi, as well as in the nasolacrimal duct, is frequently seen, 6 cases will be cited.

Miss F. M., aged 48, was seen in February 1946. The left eye had been tearing for the past six months. The left lower punctum and canaliculus were tightly swollen, but after dilation an unusually large amount of mucus was washed into the nose with irrigation. There was a high deflection of the nasal septum to the

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<sup>22</sup> Tremble, G. E. Epiphora of Nasal Origin, *Arch. Otolaryng.* **40**: 494-496 (Dec.) 1944.

left, with chronic ethmoiditis on that side. Office treatment was given once a week, and home treatment was carried out by the patient twice daily, as previously described. The discharge irrigated from the left tear sac was less on the third visit and continued to decrease on subsequent visits. On the sixth visit, the patient stated that tearing had ceased. A drop of fluorescein was rapidly transmitted from the left eye into the nose. She was advised that a severe head cold might undo the benefit she had received and that, if this should occur, an intranasal operation to improve the drainage of the left ethmoid cells was advised. In May she contracted such a cold. Despite this, the tear conduction apparatus of the left eye continued to function normally, as it had when I last heard from her, in August 1946.

Mrs S M, aged 44, was referred by the late Dr M Schoenberg in April 1943. Her left eye had teared for two years, for which she had previously been treated. The upper and lower puncta and canaliculi of the left eye were swollen tight. These were dilated, allowing free irrigation into the nose. There was chronic catarrhal involvement of the left ethmoid cells. Treatment was carried out in the office and at home, as previously described. On her third visit, a drop of fluorescein was transmitted from the left eye into the nose, but somewhat more slowly than from the right eye. On the sixth visit, in June 1943, fluorescein was transmitted from the left eye into the nose more rapidly than from the right eye.

Mrs V L, aged 43, who was referred by Dr A Levine in April 1945, complained of tearing of both eyes for over ten years, the left eye being more affected than the right. Previous treatment had not been effective. There was a pronounced deflection of the nasal septum to the left, with compensatory enlargement of the right middle turbinate bone. Incidentally, the patient complained of tinnitus of the left ear. The upper and lower puncta and canaliculi of both eyes were tightly swollen. These passages were dilated, allowing irrigation of the tear sacs. Chronic bilateral ethmoiditis was treated by displacement therapy at each weekly visit. Home treatment was ordered. On her third visit, a slight amount of fluorescein was transmitted from each eye into the nose. More dye was transmitted at the next visit. At the fifth, and last, visit the patient stated that her tearing had ceased and that the noise in her left ear was gone. She was told that a severe head cold might cause a recurrence of her symptoms and that in that case an intranasal operation to correct the sinusitis would be necessary. It is now a year and a half since her last treatment, and she has informed me that she has remained cured.

Miss E S, aged 32, was referred by Dr J Schor in October 1944 because of tearing of the right eye for over a year. Fluorescein placed in the right eye was not transmitted into the nose. After dilation of the swollen right lower punctum and canaliculus, fluorescein-stained mucus was washed through into the nose. Chronic nasal sinusitis had been present for many years. The right inferior turbinate bone was placed tight against the lateral nasal wall. A submucous resection of the nasal septum, as well as correction of the malplaced right inferior turbinate bone, was advised. Permission for operation was refused because of her pending marriage, on Christmas Day. A 10 per cent solution of silver nitrate on a cotton-tipped probe, with the end bent at a right angle, was introduced with difficulty between the right inferior turbinate bone and the lateral nasal wall and carried up into the nasolacrimal duct. The usual home treatment was ordered. Two weeks later the tearing of the right eye had diminished. When the patient was seen for the last time, a week before her marriage, tearing in the right eye had entirely ceased, and fluorescein was quickly transmitted from the right eye into the nose. It is nearly two years that her condition has been satisfactory.

N L, aged 52, referred by Dr L Bonfield in June 1945, had had tearing from both eyes for a year and a half, the right eye being affected more than the left.

The upper and lower puncta and canaliculi of both eyes were swollen. After dilation, the left tear sac was irrigated into the nose with difficulty. The right tear sac could not be irrigated. Because the patient lived at a distance, visits were fortnightly. On his third visit, the left tear sac was easily irrigated and the right tear sac could be irrigated for the first time, but with difficulty. This case demonstrates that swelling of the nasolacrimal duct may be so pronounced that several treatments are necessary before small amounts of irrigating solution can be syringed into the nose. Should such a duct be probed prematurely, injury to the swollen mucous membrane may eventuate in scar formation. The right middle turbinate bone was enlarged, causing chronic ethmoiditis on that side. Home treatment was ordered, as previously described. On his sixth visit the patient stated that tearing from both eyes had ceased. A drop of fluorescein was quickly transmitted into the nose from the left eye, and less rapidly from the right eye. Six weeks was allowed to elapse before the next visit, the patient continuing treatment at home. At the expiration of that time the better (left) eye still transmitted the dye normally into the nose, but blocking on the right had recurred. The next two visits showed that the left eye was normal, but the right sac and duct were blocked by a small amount of mucus, which prevented the transmission of fluorescein into the nose. I decided that the enlarged right middle turbinate bone would have to be treated if permanent improvement of the right eye was to be secured. This was done on October 30 with electrocoagulation and compression to about half its original size. After healing, the right eye ceased tearing. Dye was transmitted into the nose normally. When the patient was seen six months later, chronic tearing of both eyes remained cured.

A T, aged 50, was seen in January 1945 with the complaint of tearing of the left eye for six months and of the right eye for a shorter period. He wore a hearing aid. Nasal polyps had been removed twice previously but again blocked the nose bilaterally. The upper and lower puncta and canaliculi of both eyes were tightly swollen. After dilation of the upper and lower puncta and canaliculi, irrigating fluid could readily be syringed into the nose on both sides. The recurrent polyps were destroyed with electrocoagulation in several sittings. Tearing from both eyes ceased. The patient was advised that if polyps should recur soon allergic treatment, as well as ethmoidectomy, would prove of more lasting value. At the present time there has been no recurrence of tearing.

Having discussed blockage of the tear sac and the nasolacrimal duct by swelling, I shall deal with blockage caused by scar tissue. Finally, the epiphora due to obstruction of that portion of the nose into which the nasolacrimal duct drains will be considered. In order to emphasize the most useful part of this paper, I shall discuss these two conditions in the reverse of the order mentioned.

#### EPIPHORA DUE TO OBSTRUCTION OF THAT PORTION OF THE NOSE INTO WHICH THE NASOLACRIMAL DUCT DRAINS

Such obstruction may be caused by bony spurs, unusual deflections of the nasal septum, chronic swelling and greatly hypertrophied mucous membrane, polyps, cysts, tumors, scars or foreign bodies, as well as an inferior turbinate bone tightly placed against the lateral nasal wall. To cure the tearing, such an obstruction must be removed. If, in addition,

irreversible changes of the mucous membrane of the tear sac and nasolacrimal duct have occurred, these also must be removed

Three cases illustrating a few such obstructions and the methods used to remove them, are reported. Home treatment was the same as that given in the preceding group of 6 cases

Mrs L R, aged 56, was seen in September 1945. There had been tearing of both eyes for several years, the right eye being affected more than the left, and chronic irritation around the right lateral canthus for several months. She had been treated for the past four months, without relief. The chronic tearing of the right eye caused maceration of the skin at the lateral canthus, on which a fungus had grown. This fungus was brought under control. The most important finding was extreme hypertrophy of the mucous membrane of the right inferior turbinate bone, less pronounced on the left side, extending to the posterior tip, thus producing partial blockage of nasal respiration. This hypertrophic mucous membrane was destroyed by electrocoagulation, first on the right side and then, two weeks later, on the left side. Six weeks later, after reaction had subsided, the right eye ceased tearing and conducted fluorescein into the nose normally. Tearing of the left eye ceased two weeks later.

The second case is similar to the first, but, in addition, an inferior turbinate bone, tightly placed against the lateral nasal wall, was fractured toward the midline. H G, aged 68, was seen in November 1943. Both eyes had been tearing for five years, the left being affected more than the right. The upper and lower puncta of both eyes were extremely tight, especially those of the left eye. After dilation of the puncta irrigation with saline solution resulted in some mucus being washed into the nose. Twenty-five years before a submucous resection of the nasal septum had been performed. A large septal perforation and extreme hypertrophy of the mucous membrane of the inferior turbinate bones were observed. The degenerated tissue was destroyed by electrocoagulation in five fortnightly treatments. The right inferior turbinate bone, which was tightly placed against the lateral nasal wall, was fractured toward the midline. When the patient was observed on Feb 29, 1944, both eyes transmitted fluid normally into the nose. Since then he has informed me that his tearing has remained under control.

Mrs A K, aged 50, was seen in June 1945. The left tear sac had been excised in 1935. Tearing from the right eye had annoyed her for over one year. Both inferior turbinate bones were atrophic. The upper and lower canaliculi of the right eye were open, but no fluorescein was transmitted into the nose. By irrigation a small amount of solution was forced into the nose. When the patient was seen two weeks later, although no dye was transmitted from the eye into the nose, irrigation through the right lower canaliculus was easily performed, as it was at the next fortnightly visit. Careful reexamination disclosed a large scar extending from the lateral surface of the inferior turbinate bone to the lateral wall of the nose. This was cut through with the electrocoagulating current. Six weeks was permitted to elapse, by which time the reaction had subsided and tearing had ceased. Fluorescein in the right eye was quickly transmitted into the nose. The satisfactory condition continues at the time of writing.

#### REMOVAL OF SCAR TISSUE IN THE TEAR SAC AND NASOLACRIMAL DUCT

Attempts to remove obstructing scar tissue in the tear sac and nasolacrimal duct have been described by Peters in 1910 and by Dean in

1929<sup>23</sup> Schuster<sup>24</sup> (1915) described Peters' method as one of slitting the upper and lower canaliculi and perforating the stricture by constant turning of a blunted knife. If after several days the purulent secretion remains, the wound is reopened and the procedure repeated several times, if necessary. Schuster claimed a cure in 77 per cent of the cases. The failures, he stated, were perhaps due to disease of the accessory sinuses of the nose. In order to avoid failure, he stated, one should perhaps first treat the nasal sinusitis before resorting to operations on the tear sac.

Dean avoided the slitting of the canaliculi by direct incision through the skin into the tear sac. He then inserted a thick probe through the open tear sac and stretched the obstructing scar tissue until it was perforated and so dilated that an indwelling silver tube could be inserted. He found practically all the obstructions of scar tissue at the neck of the tear sac. Silver styles had to be worn for a long time, with periodic readjustments and cleaning.

#### USE OF DIATHERMY IN REMOVAL OF OBSTRUCTION IN THE NASOLACRIMAL DUCT

Worms and Filliozat,<sup>25</sup> as well as Defoug,<sup>26</sup> in 1931, followed the same procedure as did some urologists in combating stricture of the urethra by utilizing medical diathermy to disinfect as well as to restore the caliber of the urethra. Several treatments were given without the use of any local anesthetic so that the current could be regulated according to the sensation of the patient. Defoug conjectured that diathermic coagulation might prove to be the treatment of choice in cases of synechia and of stenosis of the lacrimal passages. M. Fage, in discussion on Defoug's paper, pleaded for a wider use of this modality by ophthalmologists.

In 1933 Spinelli<sup>27</sup> utilized rubber-insulated electrodes passed through an external incision of the skin into the nasolacrimal duct to cut through obstruction. A rubber tube was inserted through the opened obstruction and kept in place for twelve days.

With the area under local anesthesia, Weekers<sup>28</sup> used surgical diathermy with rubber-insulated Galezowski probes nos. 8 and 9, employ-

23 Dean, F. W. Stenosis of Lacrimal Ducts. *Arch. Ophth.* **2**: 164-168 (April) 1929.

24 Schuster, K. Zur Geschichte und Kritik der neueren Behandlungsmethoden der Tränensackeiterung, *Klin. Monatsbl. f. Augenh.* **55**: 596-611, 1915.

25 Worms, G., and Filliozat. La diathermie des voies lacrymales, *Bull. Soc. d'opht. de Paris*, March 1931, pp. 129-131.

26 Defoug. La diathermie dans le traitement de l'obliteration des voies lacrymales, *Bull. et mem. Soc. franç. d'opht.* **44**: 264-269, 1931.

27 Spinelli, F. Diathermische Rekanalisation des Tränennasenkanals, *Klin. Monatsbl. f. Augenh.* **91**: 202-207 (Aug.) 1933.

28 Weekers, L. Retablissement de la permeabilite des voies lacrymalis, *Bull. Soc. belge d'opht.*, 1932, no. 65, pp. 65-69.

ing a current of 700 milliamperes for two or three seconds. He stated that it is of course preferable to restore the structure and function of the lacrimal apparatus, rather than to detour the tears above the obstruction through an artificial opening made into the nose. The fact that three years later Weekers<sup>29</sup> published a modification to facilitate the surgical technic of the dacryocystorhinostomy of DuBois, Depuy-Dutemps and Bourguet indicates that his results were not satisfactory. This, I believe, was due principally to the improper selection and preparation of cases, and possibly the use of too strong a current. In dealing with a chronic infection of the tear sac with sticky mucopus, for example, removal of the scar tissue by destroying it with electrocoagulation may not be sufficient to cure the condition. This is likely to be the case unless by good fortune the diathermic current should have such a beneficial action on the chronically infected mucous membrane that it reduces the infected secretion and renders it fluid, so that it can drain into the nose. There are cases of sticky mucopus in which complete stricture does not exist, as is proved when strong pressure over the sac forces this viscid secretion into the nose. Nevertheless, such secretion cannot drain spontaneously into the nose.

Preliminary treatment with antiseptic, astringent solutions, sulfonamide or antibiotic preparations or medical diathermy must first be used to control the infection in the tear sac before the obstruction in the nasolacrimal duct is destroyed by electrocoagulation. As stated, if this is not done, despite the removal of the obstruction, the mucopurulent secretion is so viscid that it cannot drain through the fully opened nasolacrimal duct. It is essential therefore to give preliminary treatment to such an infection of the tear sac, as well as to the concomitant nasal sinusitis, before reopening a nasolacrimal duct closed by scar tissue. Such a procedure is likewise of advantage before performing intranasal drainage for cure of chronic infection of the tear sac, but by no means as essential. There, the wide opening of the tear sac and the electrocoagulation of its mucous membrane are adequate to drain even viscid secretion. The chronic sinusitis that is often present is alleviated by the simultaneous removal of the anterior tip of the middle turbinate bone, which is often done as part of the operation.

The method that I have followed in the removal of scar tissue in the tear sac and nasolacrimal duct inconveniences the patient so little that one is tempted to try it in many cases of infection of the tear sac. When advanced age or other conditions contraindicate surgical treatment, it is preferable to bring the infection under control as described and then remove the obstruction by electrocoagulation. If after a reasonable

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<sup>29</sup> Weekers, L. Un procede opératoire aisé et sûr de dacryocystorhinostomie, Arch d'ophth 52:241-246 (April) 1935

length of time tearing persists, intranasal drainage of the tear sac should be performed. A dilated tear sac full of sticky mucopus is best treated with intranasal drainage. I believe it is not worth while trying to cure such a condition by first combating the infection and then removing any obstruction of scar tissue, except when operation is contraindicated.

My experience<sup>30</sup> with transcanalicular incision aided by diathermy to open fully the tear sac in the intranasal operation for cure of infection of the tear sac helped me, similarly, to remove obstruction at the neck of the tear sac, as well as in the nasolacrimal duct. The same insulated electrodes can be used to open the tear sac fully, to combat threatened obstruction at the intranasal opening, to reopen such a closure occurring after any operative method formerly attempted and to destroy obstruction at any spot in or along the entire length of the nasolacrimal duct. The end of the electrode is bent at a right angle to fit the concavity of the eye socket. Electric insulating varnish is applied and baked on until hard. The ends are scraped free of the insulation.

It has been shown by Stevenson,<sup>32</sup> Dean<sup>23</sup> and others that except in congenital cases, the site of the obstruction which blocks normal conduction of tears is generally at the neck of the sac. In beginning the treatment for chronic tearing, conservative measures should be used until all abnormalities of the eyelids, puncta and canaliculi and that portion of the nose into which the nasolacrimal duct drains have first been corrected. If, after this has been done, irrigating fluid does not enter the nose after repeated trials at various sittings, one should palpate with a no. 2 or no. 3 probe for obstruction of the sac or duct. Unless care is exercised, since the bony canal is seldom straight, the swollen mucous membrane is liable to injury when the practically straight probe is pushed against it. The cautious approach here outlined will minimize such injury.

When scar tissue is palpated, usually at the neck of the sac, procaine hydrochloride, injected through a fine hypodermic needle, can be used to anesthetize the sac. At the same time the needle can be passed vertically downward into the sac, where it palpates the obstructing scar. By perforating the scar, thus allowing the solution to be syringed into the nose, one can accurately gage the thickness and toughness of the scar. In cases of traumatic origin, the entire length of the nasolacrimal duct may be filled with scar tissue. This will prevent the flow of procaine solution into the nose unless an exceptionally long needle is used to penetrate it.

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30 Morgenstern, D. J. Intranasal Drainage for Cure of Chronic Infection of the Tear Sac. Initial Transcanalicular Inverted U-Shaped Incision to Facilitate Full Opening of the Tear Sac, *Arch. Ophth.* **32** 101-103 (Aug.) 1944.

31 Footnote deleted by the author.

32 Stevenson, M. D. The Treatment of Lacrimal Obstruction, *J. A. M. A.* **49** 114-119 (July 13) 1907.

Two cases are reported in which treatment by diathermic rechanneling of the nasolacrimal duct closed by scar tissue was employed with success. In the first the tear sac was blocked by scar tissue at the neck of the sac, in the second the entire nasolacrimal duct was filled with scar tissue as a result of trauma.

Mrs. M. H., aged 58, was seen in March 1944. Both eyes had been tearing for six years, the right being first affected and soon thereafter the left. The left eye had been cured in Munich, Germany, but the right eye continued to tear. In this country she had continued treatment, without success. The right lower canaliculus had been slit. No pus could be expressed or irrigated from the right tear sac. Probing disclosed narrowing of the medial end of the right lower canaliculus and a fibrous obstruction at the neck of the tear sac. The nasal septum was conspicuously deviated to the right above, the inferior turbinate bone was atrophic. A 2 per cent solution of tetracaine hydrochloride was applied to the punctum. The right lower canaliculus was dilated to admit a no. 6 probe. A few drops of 2 per cent tetracaine hydrochloride were instilled into the tear sac. A sheet of composition metal was placed in firm contact with the patient's back to serve as the indifferent electrode. The caliber of the bent end of the insulated electrode was that of a no. 4 probe. This electrode was inserted through the dilated lower canaliculus into the tear sac. The handle of the electrode was directed horizontally away from the eye and supported so that the active tip within the sac was in firm contact with the fibrous obstruction at the neck of the sac. The amount of current used was about 1,000 milliamperes of coagulating current when short circuited. This is equivalent to about 125 milliamperes with the patient in the circuit. As soon as the current was turned on, the obstructing scar tissue gave way as the electrode readily passed vertically down the nasolacrimal duct. There was practically no reaction and no pain. When the patient returned in two weeks, a drop of fluorescein in the right eye was quickly transmitted into the nose. The patient's right eye has since continued to function normally.

Although I did not use injection of procaine hydrochloride in this case, or in the following one, I recommend its use. The purpose is primarily to perforate the obstructing scar with the needle. It thus allows the solution to be syringed into the nose, giving the operator accurate knowledge of the thickness, as well as the toughness, of the scar.

Mr. W. A., aged 67, was seen in May 1945. A fall on the sidewalk six years before had resulted in fracture of his nose, after which a purulent infection of the right tear sac set in. Painful probing had been attempted previously on several occasions, without success. In view of the patient's age and the fact that fracture results in formation of sclerotic bone, which is not easy to fenestrate, I decided first to control the infection and then to reopen the closed nasolacrimal duct. Solutions of sulfonamide drugs and of penicillin were used once a week to irrigate the tear sac, which contained only a moderate amount of infected matter. Eye drops containing a sulfonamide drug were prescribed for home use. After several weeks the tear sac was practically free of infected material. The right lower canaliculus was dilated. A 2 per cent solution of tetracaine hydrochloride was instilled into the tear sac and the active tip of the electrode placed in firm contact with the fibrous tissue blocking the neck of the sac. When the current was turned on, this scar tissue was cut through, but further resistance was encountered. With the current turned on again, the resistant scar was coagulated until the entire length



of the nasolacrimal duct, which was completely filled with scar tissue, was perforated. There was little reaction, the patient being able to return to work the afternoon of the same day. The tear sac was readily irrigated, and a no. 6 probe was passed into the nose once a week for several weeks thereafter. If any tendency to formation of scar tissue palpable with the probe should appear, the spot could be touched lightly with the coagulating electrode. It is now over a year and a half since the patient was cured, and there has been no recurrence.

In the method described, the use of styles is unnecessary. This may perhaps be explained as follows. Nature resents a surgical opening made through cranial bone, such as an opening into the antrum, an opening through the bony lacrimal fossa or the opening of a congenital bony occlusion of the choana,<sup>33</sup> and attempts to close it. Diathermy helps appreciably to reduce this tendency. In contrast to this, scar tissue obstructing the nasolacrimal duct does not show such a strong tendency to closure when opened by diathermic coagulation.

Retrograde insertion of an electrode via the ostium of the nasolacrimal duct in order to reach the obstruction at the neck of the sac, rather than the transcanalicular approach, would offer a great advantage if it were possible. The soft tissues of the canaliculi react to injury, mechanical or thermal, with swelling and possible fibrosis far more readily than do the tissues within the bony nasolacrimal duct. For this reason, it is wiser to use less current at the start. If the strength is insufficient, it can easily be increased. Unfortunately, the anatomic configuration makes the retrograde approach extremely difficult, if not impossible.

The method described in these 2 cases will find its greatest value in that small percentage of cases of congenital dacryocystitis which cannot be cured with conservative measures. In the congenital cases the block is at the lower end of the tear duct, in contradistinction to the acquired cases, in which the block is usually at the neck of the sac. In the conservative treatment of congenital dacryocystitis, Judge<sup>34</sup> advocated removal of a mass of cellular debris blocking the lower end of the nasolacrimal duct by using a cotton-tipped applicator introduced along the floor of the nose and withdrawing it just under the inferior turbinate bone. Should this procedure fail, repeated pressure with the finger over the tear sac blocking the canaliculi will open the blocked duct by hydrostatic pressure in two thirds of the cases. Antiseptic, astringent solutions are used in conjunction with this technic.

I modified this technic in the case of C. R. W., a girl aged 4 months, who was referred by Dr. L. Feit in August 1946. The right eye had been red and had

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33 Morgenstern, D. J. Congenital Atresia of the Postnasal Orifices. A Simple, Effective Office Technic for Treatment by Electro-Coagulation, *Arch Otolaryng* **31** 653-662 (April) 1940.

34 Judge, H. V. Dacryocystitis of the New Born, *New York State J. Med* **41** 25-29 (Jan. 1) 1941.

discharged pus since birth. Examination showed that the nose was clean and open. The right inferior meatus was anesthetized with a small amount of 2 per cent cocaine hydrochloride to which epinephrine hydrochloride was added. The end of a fine, cotton-tipped probe was bent at a right angle to fit under the right inferior turbinate bone and to reach the orifice of the nasolacrimal duct. In that area an abnormal, hard mound, projecting downward, was palpated with the tip of the probe. No cellular debris was found on withdrawing the probe. For this reason, a small amount of 0.5 per cent silver nitrate was applied to the area of the orifice with the same cotton-tipped probe. In addition, the mother was instructed how to exert pressure over the tear sac and to use astringent eye drops in conjunction with this technic. When I saw the referring physician in October 1946, he informed me that the baby's right eye had quickly cleared up.

To evaluate properly the efficacy of the intranasal procedure described, no other treatment should be used in conjunction with it, or it should be used in cases in which former conservative treatment has proved ineffective.

In the one third of the cases in which cure is not effected with these conservative means, Riser<sup>35</sup> advised waiting three and a half months before probing with a no. 2 probe. With these combined methods he obtained cures in 97 per cent of cases. Gifford<sup>36</sup> advised a waiting period of six months, with conservative treatment, before probing with a no. 1 probe in the cases in which such treatment was not successful. The probing should be followed immediately by irrigation with isotonic solution of sodium chloride, with the child still under general anesthesia, the head being held vertically upright and bent slightly forward to allow the irrigating fluid to run out through the nose.

There is a striking difference between the prognosis in cases of congenital dacryocystitis and that in cases of the acquired chronic type, in which conservative treatment is successful in about 50 per cent.<sup>35</sup> In all the cases in which conservative treatment fails, operation on the lacrimal drainage apparatus is required to effect a cure. An infant or child is not a proper subject for such a surgical procedure. The child therefore suffers physical as well as psychic irritation from this cause for many years. In the small percentage of congenital cases in which cure is not effected with conservative measures, the ideal method is the electrocoagulation of the blocked lower end of the nasolacrimal duct by means of an insulated electrode, with the use of chloroform anesthesia. This can be done with accuracy from above via the canaliculus, as described. By the retrograde approach, from below, the obstruction could be destroyed with less accuracy, but with a greater margin of safety to the canaliculus if an excessive amount of current should accidentally be used.

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<sup>35</sup> Riser, R. C. Dacryostenosis in Children, *Am J Ophth* **18** 1116-1122 (Dec) 1935

<sup>36</sup> Gifford, H., Jr. Dacryocystitis, *Arch Ophth* **32** 485-487 (Dec) 1944

In review, I find that in most of the cases of chronic tearing here reported there was an underlying etiologic factor of chronic nasal sinusitis. Early, conservative treatment of the tear-conducting apparatus and the concomitant nasal sinusitis will usually cure the chronic tearing. Patients who have a recurrence or those who do not adequately respond to such treatment should undergo operation for control of the chronic nasal sinusitis. In addition, it is necessary in those cases in which irreversible reactions of the nasolacrimal mucous membrane have occurred such as extreme hypertrophy, polypoid degeneration or formation of polyps, cysts or scar tissue, to deal properly with such changes. This can be done in one of two ways, depending on the pathologic changes and the physical condition of the patient. First, a new intranasal opening can be made into the tear sac above the point of blockage, followed by electrocoagulation<sup>37</sup> of the diseased mucous membrane of the tear sac. In the second, and much easier method for the operator and patient, the diseased mucous membrane may be restored after electrocoagulation with an insulated electrode inserted through the canaliculus, as described in the portion of this paper dealing with the destruction of scar tissue which blocks the nasolacrimal duct.

Small<sup>38</sup> stated

Delay permits the chronic [nasal sinus] infection to become entrenched and finally irreversible changes take place. Then simple correction of the primary intranasal pathological condition will not necessarily effect a cure of the tearing. In other words, prophylaxis should play a greater role in our treatment of chronic tearing eyes.

This, as has repeatedly been shown, points to the need of close cooperation between the ophthalmologist and the rhinologist in order to secure the best result for the patient.

#### SUMMARY

Chronic tearing may be caused by slight degrees of facial weakness, which should be looked for first.

Slitting the punctum backward in cases of such tearing is of little value. Tightening the relaxed lower lid, to bring it into close relation with the globe, by means of electrocoagulating acupuncture will cure such chronic tearing.

To reduce the incidence and severity of chronic tearing caused by weakness of facial muscles, prompt and adequate treatment is necessary.

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37 Morgenstern, D. J. Intranasal Drainage for Cure of Chronic Tear Sac Infection. New Technic Aided by Electro-Coagulation so Simplified as to Be an Office Procedure, *Arch Ophth* 27 733-745 (April) 1942.

38 Small, C. P. The Eye, Ear, Nose and Throat, Practical Medicine Series, Chicago, The Year Book Publishers, Inc., 1930, pp 31-34.

A moderately everted lower punctum is drawn back to contact the lake of tears by placing electrocoagulating acupuncture just posterior to its base

Abnormalities of the eyelids, as well as methods of their correction, are described

Abnormalities of the puncta and canaliculi, with methods for their correction, are indicated

When the canaliculi are blocked by chronic swelling, the tear sac and nasolacrimal duct are usually similarly obstructed. Treatment for the correction of these conditions is outlined

Treatment for epiphora due to obstruction of that portion of the nose into which the nasolacrimal duct drains is described

The use of diathermy to remove obstruction in the nasolacrimal duct, usually at the neck of the tear sac, is described

In that smaller percentage of cases of congenital dacryocystitis with closure of the lower end of the nasolacrimal duct in which conservative measures, including probing, prove unsuccessful, rechannelization by application of the diathermic current is ideal. Cure with this method will save a child many years of physical and psychic irritation

Most chronic tearing has an underlying etiologic factor of chronic nasal sinusitis

Delay in treating such infection "permits the chronic infection to become entrenched, and finally irreversible changes take place. Then simple correction of the primary intranasal pathologic condition will not necessarily effect a cure of the tearing. In other words, prophylaxis should play a greater role in our treatment of chronic tearing eyes" <sup>88</sup>

Close cooperation between the ophthalmologist and the rhinologist is necessary in order to secure the best result for the patient

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# THERAPEUTIC SULFADIAZINE POISONING, WITH PEMPHIGOID LESIONS

## Conjunctival Changes

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CASES of severe sulfadiazine poisoning have occurred during the course of mass prophylaxis in military personnel, but they have been relatively infrequent. Even these cases ought to be fewer, for the supervising physician has become more aware of the possibility of untoward effects and has trained himself to recognize early the symptoms of idiosyncrasy to sulfadiazine. Serious sulfadiazine poisoning is of three types—that in which the picture of agranulocytosis predominates, that which is associated with urinary suppression and that which presents widespread mucocutaneous pemphigoid lesions. I observed 3 cases of the last type at a Naval training center and found them of special ophthalmologic interest because of the characteristic conjunctival lesions which were exhibited. The systemic reactions varied in these cases, the first patient being moderately ill, the second severely ill and the third critically ill. The severity of the conjunctival lesions paralleled the general clinical course. Because of the rarity of cases of this type, a detailed account of the illnesses follows.

### REPORT OF CASES

CASE 1—*History*—D. A. J., aged 21, on Dec. 19, 1943 was given 2 tablets (0.5 Gm. each) of sulfadiazine. The medication was repeated daily in the same dose. On December 24 he received his second injection of typhoid vaccine. On December 25 a macular rash appeared on the chest and abdomen. He began to complain of photophobia and ocular pains, and simultaneously his throat became painful. It was thought that he had measles, and he was confined to the sick bay, where more sulfadiazine was given, in doses of 1 Gm. every four hours. The rash became more pronounced, and the entire body became involved. In many areas, particularly the neck, chest and abdomen, "water blisters" appeared. The bullae were preceded by considerable itching. On December 28 the patient was admitted to the hospital.

*Physical Examination*—On admission the patient appeared fairly well nourished and mentally oriented. He did not seem to be in great distress. Over his entire body was a red macular rash, discrete for the most part but coalescent in

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some areas. On the neck, chest, abdomen and back were many vesicles, ranging in diameter from 1 to 20 mm. In some regions, particularly the back and the extremities, the lesions were suggestive of measles, in other areas they were of pemphigoid character. The bullae were clear and had an erythematous base. Nikolsky's sign was not elicited. There were foul grayish membranes on the tonsils, palate and posterior pharynx. The conjunctivas were intensely inflamed, there was considerable mucopurulent discharge in the conjunctival fornices, and several small ulcerated spots, covered with the same dirty exudate, were visible on the palpebral conjunctivas.

*Therapy*—Treatment consisted in the immediate discontinuation of sulfadiazine, use of mouth washes and gargles of hot saline solution, sedation and application of 3 per cent methylrosaniline chloride U.S.P. to the base of all rupture vesicles. The eyes were cleansed frequently, and antiseptic ointments were applied.

*Laboratory Data*—December 28. Culture of material from the throat yielded no hemolytic colonies, green-producing cocci were present.

The sulfonamide level of the blood was 1 mg. or less per hundred cubic centimeters. The solution was too light to read.

December 29. The hemoglobin was 91 per cent, the red cells numbered 4,420,000, and the white cells, 6,950, with 55 polymorphonuclear leukocytes, 36 lymphocytes, 2 mononuclear cells and 7 eosinophils, per hundred cells.

The urine was normal.

*Course of Illness*—Jan. 1, 1944. The patient was improving. The mouth was still very sore. Many eroded areas were present when bullae had ruptured. The eyes were red and painful.

January 6. The cutaneous lesions were well healed except for a few crusts on the body and extremities. There was no fever. Persistent sores were present at the angles of the mouth and on the lips.

January 12. One area of erosion on the lip remained. The patient was improving.

The white cell count was 7,150, with 85 per cent polymorphonuclear leukocytes, 13 per cent lymphocytes, 1 per cent eosinophils and 1 per cent band cells.

January 25. Areas which were the sites of previous blisters showed mottling from copper-colored pigmentation. Erythema was still present in other regions. The eyes were still red and sensitive to light.

February 17. The skin was clearing slowly.

May 6. The patient had no complaints. Pigmentary deposits in the skin were still visible.

*Ophthalmic Status*. Both lids of each eye showed extensive superficial scarring of the conjunctiva. The scars were thin, sheetlike and bluish white. Some were stellate. They contained many newly formed vessels, which for the most part coursed in the same direction as the scar fibers. The scarring was not uniform. The plaques of scar tissue radiated in all directions. The edge of the scars in the lower lids was slightly raised, but no passage could be effected beneath this edge. A few small cysts were visible beneath the scarred surfaces in the upper fornices, just beyond the upper tarsal limits. Several small fan-shaped extensions of the scars passed to the margins of the lids. A small venous varix was present under the conjunctiva of the lower fornix of the right eye.

The patient experienced little discomfort. The eyes did not feel dry, and the normal amount of moisture seemed to be present. The corneas and bulbar conjunctivas were normal.

June 1944 When the patient was last seen, nearly one-half year after the initial complaints, the conjunctival picture had not materially altered

CASE 2—A E W, aged 19, took sulfadiazine in prophylactic doses of 1 Gm daily from Feb 7 until March 5, 1944 On the latter date there developed coryza, soreness of the eyes, mouth and throat and fever He was admitted to the sick bay with the diagnosis of catarrhal fever and was given additional sulfadiazine in doses of 2 Gm four times a day On March 13, the eyes became much more painful, and he noticed a red macular rash on the hands and feet That evening his mouth became very painful, and he experienced difficulty in swallowing Administration of sulfadiazine was continued through the evening of March 14, but the symptoms became exacerbated, with balanitis and extension of the rash to the neck and body His temperature was 100 F On March 15 he was admitted to the hospital with the suspected diagnosis of measles and Vincent's angina

*Physical Examination*—On admission, the patient was uncomfortable, ill but well oriented A maculopapular erythema, sparse over the body, but more generalized on the neck, arms and legs, was evident. The lesions varied in diameter from 1 to 6 mm A few had small vesicular centers The rash was



Fig 1 (case 1)—Stellate scarring of conjunctiva of the upper lid The edges of the scar are undermined

confluent on the neck, the upper part of the chest, the shoulders and, particularly, the feet In general appearance it resembled erythema multiforme

The lids were swollen and red, and the conjunctivas were intensely inflamed Considerable purulent discharge was present The bulbar conjunctivas were also greatly reddened No conjunctival erosions were seen

The mouth was sore, and the lips were swollen and denuded, with exudate covering the raw areas Exudate-covered erosions on the palate, uvula and buccal mucosa were noted The nasal mucosa was red and crusted The pharynx was relatively clear The glans penis was eroded and red, with purulent exudate There was minor generalized lymphadenopathy

*Laboratory Data*—The blood count was normal The sulfadiazine level of the blood was 10 mg per hundred cubic centimeters The urine was normal

A smear of the conjunctival discharge revealed gram-positive diplococci Culture of material from the conjunctiva yielded staphylococci and cocci in tetrad formation (probably *Micrococcus catarrhalis*) The sedimentation rate was 13 mm in the first hour The white cells numbered 10,400, with 78 polymorphonuclear leukocytes, 19 lymphocytes and 3 mononuclear cells, per hundred cells

*Course*—March 16 The sulfonamide level of the blood was zero

Treatment was essentially the same as that in case 1

March 28 The oral mucosa was still unhealed The patient was afebrile and felt well

April 11 The lips had finally healed The eyes were fairly comfortable

August 18 A smear of material from the conjunctiva showed few gram-positive diplococci and no pus cells

September 18 Examination of the lids six months after hospitalization revealed the following condition

The conjunctiva of the right upper lid contained several large stellate scars The arrangement of the blood vessels around these scars was interesting Perhaps a dozen vessels emerged from the deeper layers of the conjunctiva, to surround each scar, they extended inward, giving off small twigs but not quite

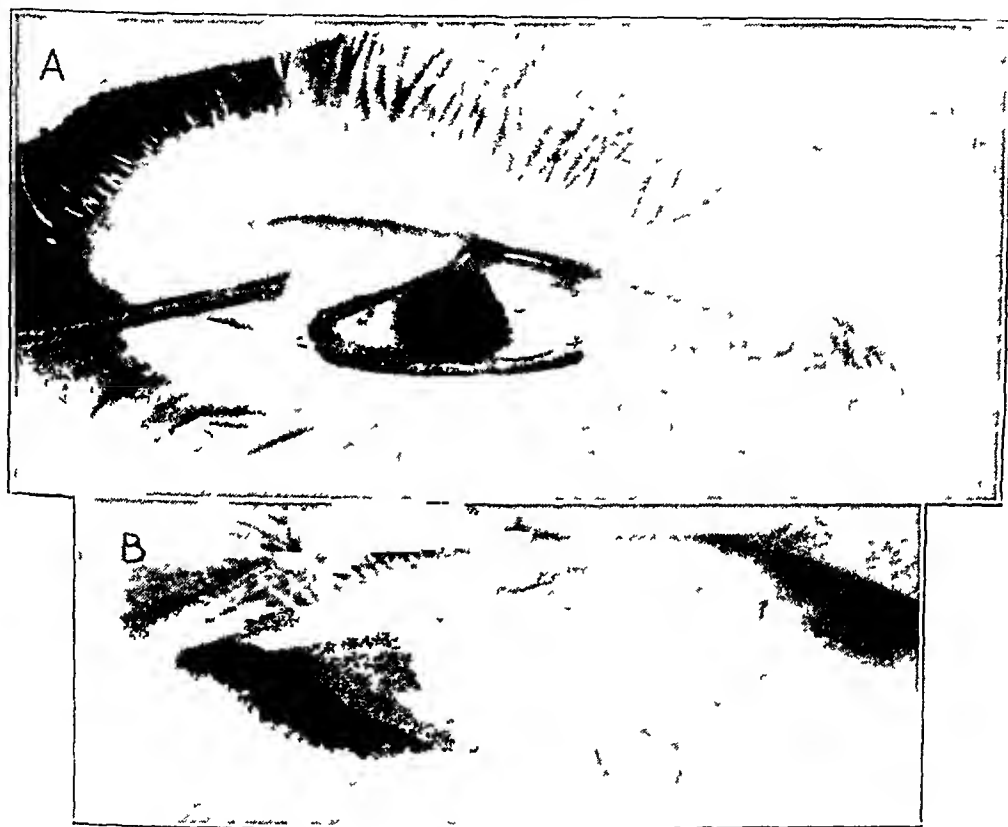


Fig 2 (case 2)—*A*, partial epitarsus of the upper lid of the right eye A similar epitarsus is present nasally *B*, extensive scarring of the upper palpebral conjunctiva of the left eye Small subconjunctival cysts are evident nasally

reaching the center of the scar Avascular islands of scar tissue thus appeared to be surrounded with a radiating corona of blood vessels A partial epitarsus was present (fig 2*A*) A fold of temporal bulbar conjunctiva extended from the globe to the lid A shallow conical conjunctival pocket was thus formed, with the mouth opening laterally and the tip of the pocket at the middle of the upper tarsal edge

The right lower lid appeared normal except for a thin linear scar parallel to its margin

The left upper lid presented a large smooth scar, extending from the upper tarsal border nearly to the margin of the lid, about one-half the conjunctival surface was occupied by this scar, which was oblong This area was sparsely



vascularized, a fact readily demonstrated by exerting slight pressure against the everted lid. The remaining conjunctiva was thickened but fairly smooth, and was intensely red. A few fine, faint scars were evident near the margins of the lid. A partial ep tarsus, similar in appearance to that of the right lid, was present on the temporal side (fig 2 B).

The left lower lid was much less reddened and contained a narrow linear scar running nearly the entire length of the lid, close to the margin. Near the outer angle was a cyst of a meibomian gland, transparent on transillumination and surrounded by a zone of bluish black pigment. At the nasal portion of the lid, on the conjunctival surface, was a healed ulcer, the base of which was filled with small red follicles.

A slight amount of mucoid secretion was present on all the lids. The patient was well enough for duty, but the eyes were still irritated.

**CASE 3**—J. L. W., aged 26, took sulfadiazine in prophylactic doses of 1 Gm daily from Feb 7 to Feb 24, 1944. On February 25 he was admitted to the sick bay, complaining of a "cold" and sore eyes. He was treated for incipient measles, with larger, but unrecorded, doses of sulfadiazine. He soon presented severe conjunctivitis, a maculopapular rash on the chest and a morbilliform rash on the feet and body (fig 3). The throat was congested, with a membrane over the pharynx. Severe stomatitis was present. There were diminished breath sounds over both lungs and rales in the bases of both lungs.

The patient was admitted to the hospital on February 26. His eyes were swollen and red, his lips were excoriated, his throat was inflamed and covered with a dirty white exudate. The gums were edematous and bleeding, the breath was foul. The body was covered with a confluent rash. A diagnosis of malignant measles was made and the patient was given sulfadiazine, 1 Gm every four hours. On February 27 the temperature rose to 102.4 F. The entire body was covered with the rash, and vesicular and bullous lesions made their appearance. The pemphigus-like blisters were most extensive over the face, chest and back. The condition was recognized as a reaction to sulfadiazine, and administration of the drug was immediately discontinued. A transfusion of 500 cc of blood was given, and injections of penicillin, 100,000 Oxford units daily, were instituted. Sedatives were prescribed, fluids were forced, cool saline packs were applied to the face, and the bed was liberally powdered.

**Course**—February 29. The patient continued to be febrile (102 F). There was considerable cutaneous discomfort, the eyes were sore, and the mouth was raw. He was almost completely covered with vesicles, and the skin in the vesicular areas was brownish or dusky. The epithelium had stripped off about the lids, leaving large erosions. The conjunctival surfaces of the lids showed erosions which were covered with a dirty exudate. The nasal mucosa was congested, and the lips were swollen. The genitalia were involved. The soles were covered with one massive bulla.

A roentgenogram of the chest revealed nothing significant. The blood count was essentially normal. Rales, due to exudative bronchitis, persisted in both lungs.

March 2. The urine gave a 1 plus reaction for albumin and contained a few red cells.

March 6. Copious yellow exudate was obtained from the mouth and throat. The patient coughed considerably. He complained of retrosternal burning and epigastric pain.

March 7. The condition was somewhat better. The skin showed only a few new vesicles, these were superficial and lay in the uppermost part of the stratum

corneum The rest of the skin was healing without infection, except for the vermillion border of the lips The lips were swollen A red "butterfly" was present over the nose, with broken blisters and sloughed skin The eyes were slowly improving in appearance A roentgenogram of the chest revealed a small amount of fluid at the base of the left lung

March 13 The dose of penicillin was gradually reduced to 25,000 units daily Considerable postinflammatory pigment was visible in the skin The mouth

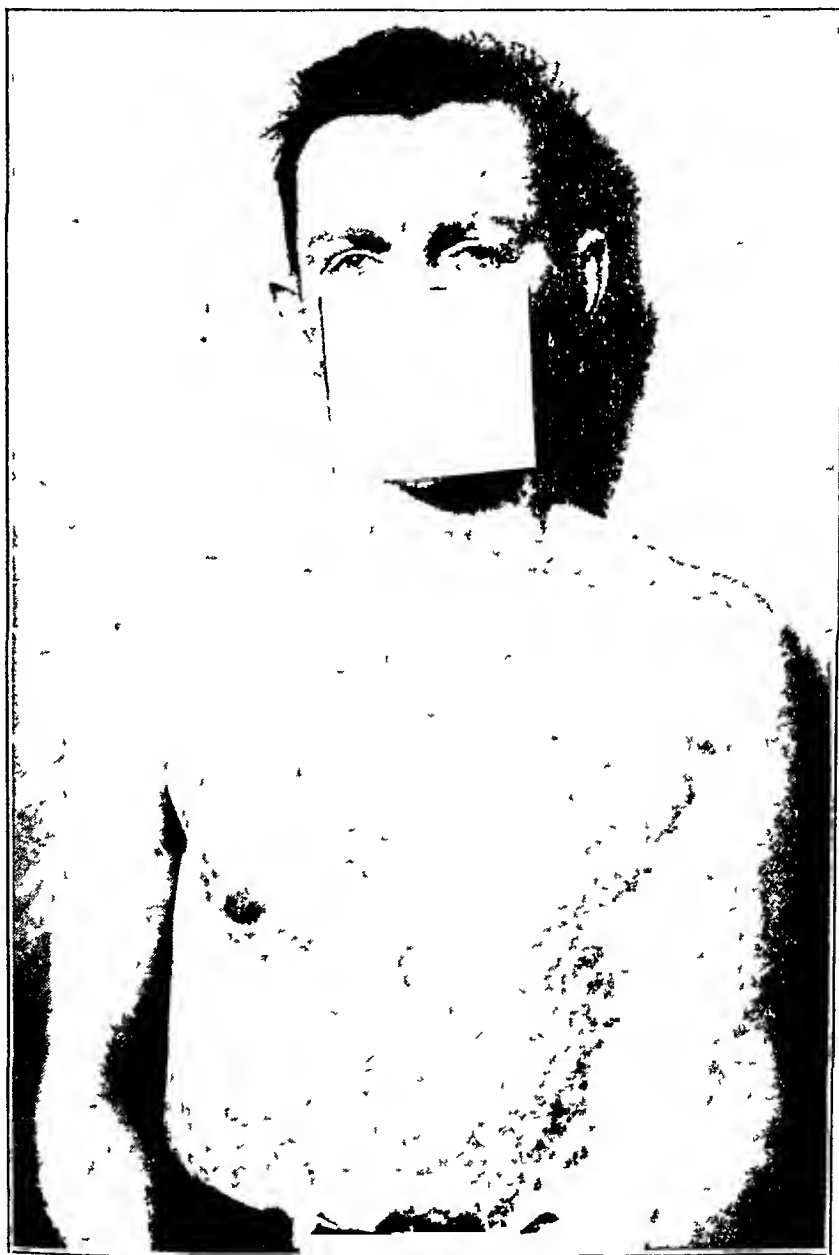


Fig 3 (case 3)—Diffuse, copper-red motting of the skin of the face and body The rash persisted for over a year

was still raw The glans penis was denuded, and the scrotum was red and oozing The lids continued to improve slowly

March 17 The patient complained of pain in the left calf and along the inner aspect of the thigh, from the popliteal area to Poupart's ligament There was a sharp rise in temperature

March 18 Pain was present in the lower part of the abdomen, being due probably to thrombophlebitis at the bifurcation of the inferior vena cava

March 20 The patient had a sudden onset of severe pain, localized in the left side of chest, in the region of the seventh and eighth ribs near the anterior axillary line. Infarction of the pulmonary artery was suspected

March 21 A roentgenogram showed the absence of infarct. The fluid was gone. A friction rub was audible. The pain may have been due to pleural roughening, which became evident on resorption of the fluid

April 6 The patient was doing well. The white cell count was 18,000, with 5 per cent eosinophils

April 18 There was moderate edema of the left leg and ankle, with pain along the outer aspect of the thigh

April 27 Redness of the left eye was increased, with edema of the lids

April 28 There was slight ptosis of the left upper lid. Vision was 20/20 in the right eye and 10/20 in the left eye

May 2 An ophthalmologic consultation was held. The fundi and corneas were normal. The conjunctivas of both eyes were inflamed and thickened and showed irregular scarring, with contraction of the scar tissue, particularly in the lower fornices. There was a tendency to dryness in the healed areas. A large conjunctival cyst was present in the upper fornix of the left eye and a small cyst in the lower fornix of the right eye. All the lids showed ep tarsal adhesions. The conjunctival lesions simulated pemphigus and must be classified as pemphigus-like lesions, part of a generalized reaction to sulfadiazine. The patient complained of tearing. Both lower lids were becoming everted, especially the left. Both lower puncta, particularly that of the left eye, were involved in the process of shrinkage. Fluid passed through both lacrimal canals, but not readily

June 10 The puncta were difficult to find

An indolent ulcer had appeared on the anterior aspect of the left tibia

Ophthalmic status. The conjunctiva of the upper lids had become thickened, velvety and edematous, with multiple small and large cysts (fig 4A). Two ep tarsal membranes formed connections with each lid. These formed two wide pockets, with the respective stomas at the temporal and nasal edges of the lid, and ended near the center of the lid, but were not connected with each other

The conjunctiva of the lower lids represented a later stage in the healing process. It showed a tendency to dryness on portions of the lids and fornices. Scarring was extensive and passed over to the margins of the lids, at the same time, the epithelium from the lid margin extended in some areas to the conjunctival surface. The bulbar epithelium was puckered with scars. A probe could be passed under the ep tarsus in the lower fornix from a nasal opening along the entire length of the lid, but the channel ended blindly at the temporal extremity. An unusual feature was the presence of circular ulcers, ranging in diameter from the size of a pinpoint to about 2 mm (fig 4B). They were located chiefly in the scarred area, but were visible in otherwise apparently normal islands of conjunctiva. When seen with the slit lamp, they were startlingly reminiscent of the hole in a grayish detached retina. The edge of the ulcer was undermined in some instances and could be explored with a toothpick to a depth as great as 1 mm. The floor usually contained grayish or yellowish debris. The ulcers at times were covered with a transparent layer of epithelium, beneath which could be seen small yellowish, fatty globules. A similar fatty infiltration was visible on the margins of the lids. The meibomian glands were prone to form serous cysts, which could readily be transilluminated and around which black pigment was deposited. Distichiasis was present

Application of sulfadiazine powder or ointment to the lids was well tolerated and produced no reaction

October 1944 When the patient was last seen, eight months after the onset of symptoms, the conjunctival picture had not materially changed He complained of tearing and moderate irritation of the lids A slight discharge was noticeable The pigmentation over the body had begun to fade

The lower epitarsal membranes had previously been resected, and the larger conjunctival cysts had been removed Sections of an epitarsal membrane showed



Fig 4 (case 3) —*A*, multiple cysts of the conjunctiva of the upper lid The conjunctiva is thickened and velvety *B*, epitarsus of the lower fornix Three circular conjunctival ulcers are present on the lower lid Each is surrounded by a zone of inflammation

normal conjunctival epithelium in a double fold, with connective tissue filling the space between (fig 5) A sparse round cell infiltration was present in the connective tissue

A conjunctival ulcer with the adjacent conjunctiva was excised for pathologic examination The report, by Col J E Ash, director of the Army Medical Museum follows

"Examination disclosed a conjunctival ulcer, the base of which was coated with inflammatory exudate. The margins were widely undermined and epithelized (fig 6). The local lesion itself was nonspecific. The sequence of events suggests that the integumented interruption was a reaction to sulfadiazine. The persistence of the conjunctival lesion after regression of the cutaneous eruption was probably due to the epithelial downgrowth at the margin of the ulcer."

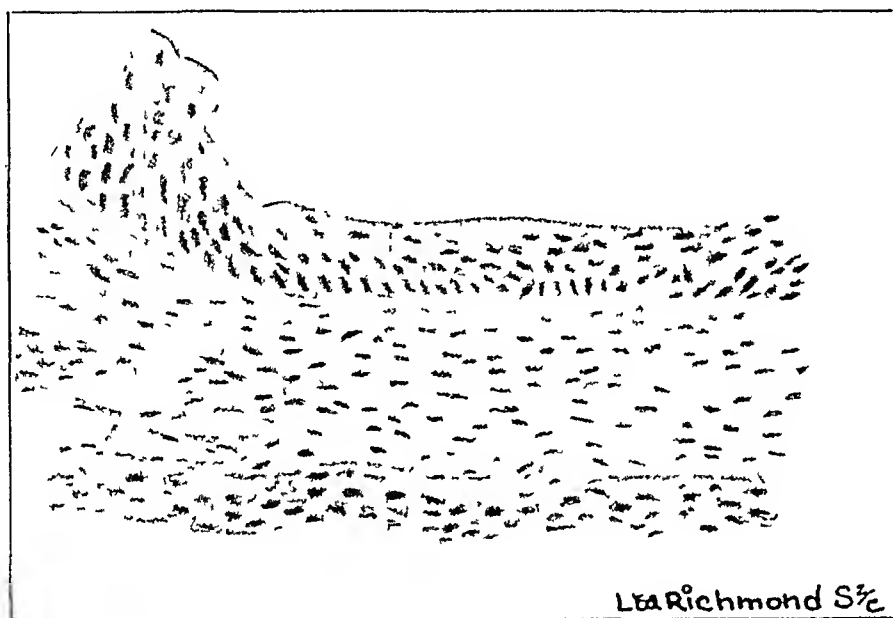


Fig 5—Section of the epitarsus. There is a clear basement membrane under one of the epithelial surfaces.

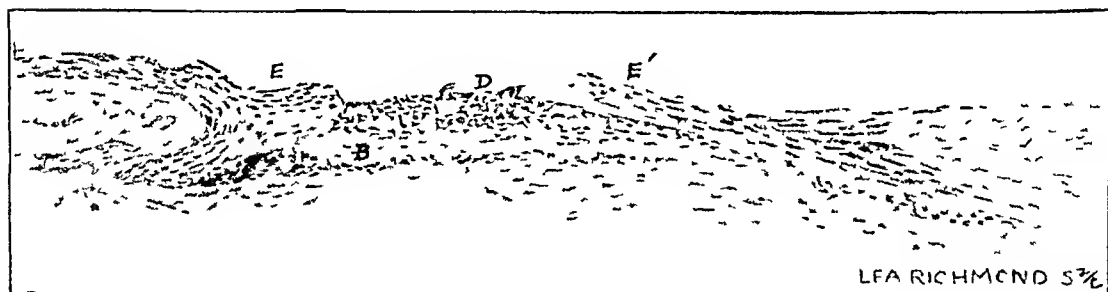


Fig 6—Cross section of the conjunctival ulcer. The edges *E* and *E'* are undermined and epithelized. The base of the ulcer contains cellular debris (*D*). The epithelium is attempting to bridge the floor of the ulcer at *B*.

#### COMMENT

In large military establishments, where contagious diseases are prevalent and the possibility of their appearance is constantly kept in mind, the early evidences of sulfadiazine poisoning may lead to the mistaken diagnosis of scarlet fever or measles. If administration of

sulfadiazine is not discontinued, the reaction may simulate malignant measles or acute pemphigus. The conjunctival lesions in cases of sulfadiazine poisoning consist at first of large ulcerations, conjunctival thickening and formation of cysts, and then of extensive scarring. The edges of the scars are frequently undermined. There are persistent thickening and inflammation of the unscarred epithelium. The initial ulcers heal. Later, small circular ulcers of the palpebral conjunctiva, with undermined epithelized edges, apparently caused by rupture of some of the cysts, may appear and persist for well over half a year. Many of the cysts remain unruptured. Epitarsal membranes on both the upper and the lower lid are a part of this unique picture, their mode of formation is not clear. Tearing may be caused by narrowing, distortion and eversion of the puncta. The cornea is not affected.

In differential diagnosis, one must consider the *ectodermosis erosiva pluriorificialis* form of erythema multiforme, true pemphigus and measles. A history of ingestion of sulfadiazine is enough to predicate the diagnosis of therapeutic sulfadiazine poisoning, sulfadiazine crystals in the urine and the presence of sulfadiazine in the blood are confirmatory evidence. The ordinary form of erythema multiforme does not leave permanent changes, *ectodermosis erosiva pluriorificialis* almost invariably involves the cornea. The condition described differs from true pemphigus in the epitarsal membranes and the punched-out conjunctival ulcers, there is not the specific histologic picture observed in cases of true pemphigus. However, in referring to the cutaneous lesions, the dermatologist expressed the following opinion: "This reaction resembles acute pemphigus, supporting the belief that the latter is a toxic process and may be due to drug intoxication."

Treatment must be symptomatic. The general condition of the patient must be supported by blood transfusions, infusions of dextrose and administration of penicillin. The skin must be kept clean and protected. Bland eye washes and ointments help to relieve discomfort. Secondary conjunctivitis may be superimposed, and this is controlled with the usual antiseptic remedies. Large cysts should be excised. Eversion of the lids and stenosis of the puncta must be dealt with surgically.

6 West Seventy-Seventh Street

## SELENIUM BURN OF THE EYE

Report of a Case, with Review of the Literature

J MYRON MIDDLETON, M D

LOS ANGELES

**S**ELENIUM and its compounds are used extensively in the arts and in industry, but relatively little has been reported in this new field

The element selenium was discovered by Berzelius in 1817, it is intimately related to sulfur, arsenic and tellurium and shares many of their physical and chemical properties. In addition to the element itself, some of the commonly used compounds are hydrogen selenide, sodium selenide, selenium dioxide, selenium oxychloride, selenious acid and its salts sodium and potassium selenite, and selenic acid and its salt sodium selenate.

The compounds of selenium are used in the manufacture of ruby glass, as well as in decolorizing glass. They find a place in the production of pigments for paint and ink and in coloring plastics. In metallurgy, they are used in the manufacture of stainless steel and copper alloys. They are also used extensively in the rubber industry, in fireproofing of electric cables and in photoelectric equipment. They are used as well in the manufacture of insecticides, general chemicals, cement and lime.

### REVIEW OF THE LITERATURE

No case of selenium burns of the eye can be found in the literature. Reports of cutaneous manifestations and generalized intoxication in man are few.

Dudley<sup>1</sup> reported a self-induced, third degree burn of the skin of the forearm with selenium oxychloride, which was slow to heal. The same author demonstrated the vesicant properties of the substance on the skin of rabbits, as well as its extreme general toxicity. Three episodes of finger nail burns, with loss of nail substance, were reported by the patient himself.<sup>2</sup> Pringle<sup>3</sup> reported 5 cases of burns, derma-

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1 Dudley, H C. Pub Health Rep 53 94, 1938

2 Personal communication to the author

3 Pringle, P. Brit J Dermat 54 54, 1942

titis and sensitivity to selenium among industrial workers. He stated that the molten metal apparently produces lesions of less severity than its salts, for the metal burns were primarily thermal. Ellis and associates<sup>4</sup> noted the experimental production of exophthalmos in fish by intraperitoneal injection of sodium selenite—intense edema of the orbital fat resulted.

In the acute form (acquired type) of poisoning, selenium produces "blind staggers" in cattle. In the chronic form of selenosis no ocular involvement is observed. Ophthalmologic observations are few, but Stenn<sup>5</sup> offered an excellent picture of selenosis in the eyes of cattle.

The eyelids are edematous, and lacrimation is profuse. The aqueous becomes swollen and turbid, and the cornea often shows a hemorrhagic opaque white mass protruding beyond the curvature of the eyeball, making the limbus of the cornea indistinguishable.

#### GENERAL TOXIC ACTION

Selenium has many toxic effects. It is transmitted through the placenta of poultry.<sup>5</sup> In the progeny of poultry fed diets high in selenium, absence of one or both eyes, cyclops and rudimentary eyes have been reported.

Selenium compounds are extremely lethal, as evidenced by the toxicity of undiluted selenium oxychloride ( $\text{SeOCl}_2$ )<sup>1</sup> which caused the death within twenty hours of rabbits receiving 0.1 cc of the oxychloride to one area of the skin surface.

Smith and associates<sup>6</sup> showed that the principal concentration of selenium was in the parenchyma, in combination with tissue protein, and that 75 per cent was excreted through the kidneys. Shultz and Lewis<sup>7</sup> reported that 17 to 52 per cent was excreted by the lungs as a volatile compound.

Twomey and Twomey<sup>8</sup> reported cerebellar hemorrhages in ducks fed selenium. Experimentally in rats, focal necrosis was noted in the liver, hematopoietic system, lungs, kidneys and heart. By con-

4 Ellis, M. M., Motley, H. L., Ellis, M. D., and Jones, R. O. *Proc. Soc. Exper. Biol. & Med.* **36**: 519, 1937.

5 Stenn, F. "Alkali Disease"—Selenium Poisoning, *Arch. Path.* **22**: 398 (Sept.) 1936.

6 Smith, M. I., Stohlman, E. F., and Lillie, R. D. *J. Pharmacol. & Exper. Therap.* **60**: 449, 1937.

7 Schultze, J. and Lewis, H. B. *J. Biol. Chem.* **133**: 199, 1940.

8 Twomey, A. C., and Twomey, S. J. *Science* **83**: 470, 1936.



trast, the low concentration in the brain is striking. Uremia and ascites were prominent features. Fitzhugh and associates<sup>9</sup> reported the occurrence of hepatic adenocarcinoma in rats after protracted ingestion of selenium.

Clark<sup>10</sup> stated that selenium resembles sulfur compounds, however, selenium inhibits cellular respiration, whereas sulfur is intimately associated with the discharge of respiratory function. Selenium replaces sulfur in compounds, resulting, for example, in cystine combined with selenium instead of with sulfur. Thus, it creates a sulfur deficiency in animals by replacing the sulfur in cystine and keratin. Selenium exerts an inhibitory effect on enzymes, it may possibly inhibit glycolysis. Amor and Pringle<sup>11</sup> stated that, although in general selenium is chemically similar to sulfur and tellurium, its toxic action resembles that of arsenic. In general it has a toxic action on oxidative processes. It is irritative as well as inhibitory. Tolerance does not develop. Amor stated that selenium poisoning in man resembles pellagra.

Lemley<sup>12</sup> reported cases of selenosis with dermatitis in man and the beneficial effect of bromobenzene. A high protein, low carbohydrate intake was found to protect rats fed diets high in selenium.<sup>13</sup> Rhian and Moxon<sup>14</sup> found arsenic effective in prevention and treatment of selenosis in dogs. Waters and Stock<sup>15</sup> reported the preventive and therapeutic value of 2,3-dimercaptopropanol (BAL) in poisoning with trivalent arsenic, the biochemical mechanisms of which are similar to those of selenium.

The local effects are principally irritative, as evidenced by irritation of the nose and throat, dermatitis and vesication (Dudley,<sup>1</sup> Pringle<sup>3</sup> and others). Selenium salts produced third degree burns of the skin, attended with severe induration, deposits of the element selenium and delayed healing.

#### REPORT OF CASE

W. A. Z., a chemist aged 36, was accidentally sprayed with selenium dioxide at 9 a. m. on Dec. 13, 1944, sustaining burns of both eyes, the entire face and the

9 Fitzhugh, G. O., Nelson, A. A., and Bliss, C. I. *J. Pharmacol. & Exper. Therap.* **80**: 289, 1944.

10 Clark, A. *J. Trop. Med.* **43**: 250, 1940.

11 Amor, A. J., and Pringle, P. *Bull. Hyg.* **20**: 239, 1945.

12 Lemley, R. E. *Journal-Lancet* **60**: 528, 1940.

13 Smith, M. I. *Pub. Health Rep.* **54**: 31, 1939.

14 Rhian, M., and Moxon, A. L. *J. Pharmacol. & Exper. Therap.* **78**: 249, 1943.

15 Waters, L. L., and Stock, C. *Science* **102**: 601, 1945.

back of the neck. He irrigated the parts immediately with tap water and presented himself for treatment in the receiving ward of the Philadelphia General Hospital.

He had a past history of episcleritis and iritis of the left eye in 1942 and of spondylosis chronica ankylopoietica of many years' duration.

When he was seen in the receiving ward of the Philadelphia General Hospital one hour after the accident, burning, pain and lacrimation were severe and spasm was extreme. There was intense injection of the palpebral and bulbar conjunctivas. The corneas and conjunctivas took no stain with fluorescein. There were several old posterior synechias in the left eye, but the pupils were round, regular, equal and active in direct and consensual response. There were first degree burns of the lids, the upper part of the face and the lower part of the neck. The eyes were freely irrigated with isotonic solution of sodium chloride, phenocaine ("holocaine") hydrochloride was instilled, and a bland ointment was applied to the skin of the lids. After this the patient was discharged. Six hours later he returned, complaining of severe, persistent, intolerable pain in both eyes, with lacrimation and photophobia. Grossly, vision was unimpaired.

Examination at that time revealed intense chemosis of the bulbar conjunctiva and beginning marbleization of the lower half of the bulbar conjunctiva, below each cornea. These areas, as well as the lower one fourth to one third of each cornea, stained deeply, with a flat line of demarcation above, corresponding to the line of the upper lid. The patient was then admitted to the Philadelphia General Hospital and placed under treatment with 1 per cent atropine sulfate, "metycaine hydrochloride ophthalmic ointment 4 per cent," and codeine and acetylsalicylic acid as needed. On his admission, 1,500 cc of isotonic solution of sodium chloride was given intravenously.

Sixteen hours later vision was definitely blurred. There were exaggeration of all symptoms and considerable discharge of thick, white mucoid material at the margins of the lids. Edema of the lids, however, was reduced. The bulbar conjunctivas had progressed to almost complete marbleization, and the lower three fourths of each cornea was dulled. This entire area stained deeply with fluorescein.

Topical application of a solution of penicillin, 500 units per cubic centimeter, was instituted every hour, as well as continuous application to the face of packs saturated with saline solution (use of ointments was discontinued).

On December 14 the patient was seen in consultation by Dr. Alfred Cowan and Dr. Francis Heed Adler, and the following conclusions were reached:

- 1 It was too late to use 2,3-dimercaptopropanol (BAL).
- 2 The ophthalmologic prognosis should be guarded because of the extreme ischemia of the bulbar conjunctiva.
- 3 It was advisable to consider the future necessity of mucous membrane grafts if the corneal slough continued.

On December 15, with the use of anesthesia induced by the intravenous administration of pentothal sodium, a mucous membrane graft, 12 by 8 mm, was applied beneath the limbus of the right eye. The postoperative course was complicated by pulmonary atelectasis, which cleared within twenty-four hours.

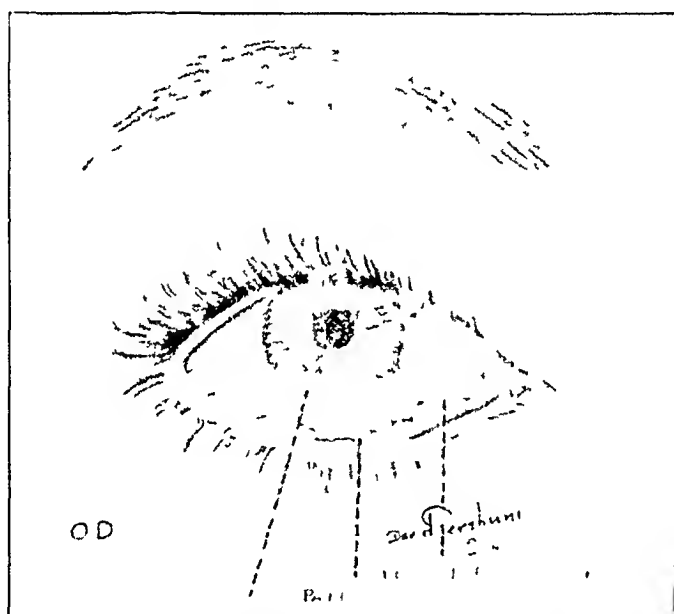
The patient continued to have a slight foreign body sensation. Ulceration appeared slightly deeper. However, the uninvolved areas of the cornea retained normal luster and took no stain with fluorescein.

The conjunctiva of the lower one half of each eye remained marbled, dull, rough and thickened and stained with fluorescein. A deep ciliary flush appeared at the lower part of the limbus, from 4 to 8 o'clock.

Early adhesions appeared in the lower cul-de-sac and the corneal erosion seemed deeper.

On December 16 the corneas began to clear from above downward. The mucoid discharge was more profuse in the right eye and adhesions were definitely formed, being most conspicuous near the caruncle. By the following day the upper one half of the right cornea had cleared.

On December 18 the entire right cornea was clear but photophobia was severe. However, the graft was well vascularized and attached, and the right cornea did not stain with fluorescein. Pallor persisted in the lower portion of the bulbar con-



End result of a mucous membrane graft to the right eye in repair of corneal sloughing, which resulted from a selenium burn.

conjunctiva, being more pronounced in the left (ungrafted eye). The left cornea still stained below.

On December 29, sixteen days after admission, the patient was discharged. Naked vision was 6/9 in the right eye and 6/6 in the left eye. Both eyes were almost completely quiet. Several fine adhesive bands remained in the lower cul-de-sac of the grafted eye. The graft was elevated and produced a moderate degree of ectropion of the lower lid, as well as a partial pannus of the lower one sixth of the cornea.

The patient's subsequent course was unsatisfactory, in that conservative measures, consisting of the use of triglyceride of tannic acid and 2 per cent silver nitrate and massage, failed to flatten the graft, although it lost a degree of lividity.

Fourteen months later, mild ectropion of the right lower lid was observed to persist. Lacrimation was troublesome. The cosmetic appearance of the graft was

unfavorable Beta roentgen irradiation was decided against, and surgical removal of the graft was planned

#### COMMENT

Most selenium compounds are vesicants. They are acid in reaction, and their toxic action on tissue is the same as that of any strong acid, producing severe burns, which are slow to heal.

In the case reported, replacement of the sulfur in keratin by selenium heightened the otherwise simple trauma of a burn. Tissue destruction was not immediately apparent, but it was slowly progressive for several hours and was then demonstrated by staining. The value of any late treatment may be questionable, for the selenium will already have combined with tissue proteins.

In this case, the mucous membrane graft was seemingly not necessary. However, with no previous experience in the treatment of selenium burns and with the severe involvement of both eyes by a chemical of unknown toxic action, it was deemed advisable to resupply corneal nutrition quickly. The grafted eye recovered more promptly, but the graft led to postoperative ectropion, partial symblepharon, astigmatism and an undesirable cosmetic result. (The mucous membrane flap may have been too thick.)

The therapeutic value of 2,3-dimercaptopropanol (BAL) in the acute phase of the disease was considered.

#### SUMMARY

A case of selenium burn of the eye, together with a review of the literature, is presented. A mucous membrane graft was made, but, in retrospect, the procedure may have been unnecessary. Intravenous administration of fluids was used to combat a possible toxic level of absorption. It was felt that 2,3-dimercaptopropanol (BAL) therapy might have been the ideal method. Complete recovery from acute symptoms occurred within ten days.

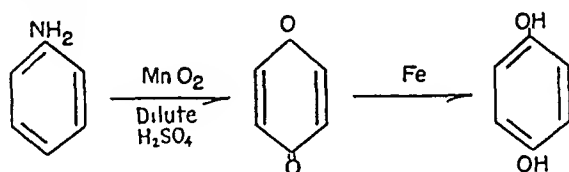
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# CORNEAL AND CONJUNCTIVAL PIGMENTATION AMONG WORKERS ENGAGED IN MANUFACTURE OF HYDROQUINONE

BANKS ANDERSON, M D  
DURHAM, N C

OCULAR lesions developing in workers exposed to aniline or its derivatives have been previously reported MacKinley,<sup>1</sup> in 1886, reported brown discoloration of the cornea and conjunctiva in an aniline plant worker with slight reduction in vision In 1897 Senn<sup>2</sup> observed among 32 workers in aniline dye 18 with sepia brown staining in the interpalpebral zone In 10 of these workers only the conjunctiva was stained, in 8 the cornea was involved Senn postulated that this staining was due to the oxidation product of aniline, viz, paraquinone K Velhagen Jr<sup>3</sup> collected a series of 6 cases of workers in hydroquinone plants with lesions of the conjunctiva and cornea of various degrees similar to those developing in workers described in the present report

Since the manner in which the persons involved in this study were exposed to the chemical is a problem of industrial hygiene rather than one of ophthalmology, I shall limit myself to a brief description of the chemical reactions which occur in the manufacture of the substance Quinone in this instance is produced by the oxidation of commercial aniline oil by means of manganese dioxide in the presence of aqueous sulfuric acid The quinone distilled from this reaction mixture is then reduced to hydroquinone by the addition of iron dust Disregarding the rather intricate mechanism involved in the oxidation, distillation and reduction of the compound, one may write the equation for the end product as follows



From the Division of Ophthalmology, Duke University School of Medicine

1 MacKinley, J G Intense Pigmentation of Corneae and Conjunctiva, Tr Ophth Soc U Kingdom 6 144, 1886, cited by Velhagen<sup>3</sup>

2 Senn, A Typische Hornhauterkrankung bei Anilinfarbern, Kor-bl f Schweiz Aerzte, 1897, p 161, cited by Velhagen<sup>3</sup>

3 Velhagen, K, Jr Chinonverfarbung der Lidspaltenzone als Gewerbe-krankheit in der Hydrochinonfabrikation, Klin Monatsbl f Augenh 86 739, 1931

The raw materials from which this chemical is manufactured are processed by gravity under heat and pressure through various mixing and distilling vats, filter presses and weighing machines, to emerge in the packing room as the pure compound. Although ventilation is provided and the system is enclosed, fumes and dust particles escape into the atmosphere of the plant and produce the lesions to be described.

The cases reported in this study have, because of potential visual loss and cosmetic blemish, become a matter of concern. I was, therefore, invited to make a survey of the personnel of the plant with the idea of obtaining information relative to the following points: (1) number and types of ocular injuries, (2) manner in which the injuries were incurred and any correlations as to age, duration of employment or other factors producing the lesions, (3) consideration of treatment, (4) estimation of prognosis, (5) prevention of further injury.

#### NUMBER AND TYPES OF OCULAR INJURIES

Arbitrary, but workable, standards were set up for grading the severity of the lesions. It early became apparent that there was not necessarily any correlation between the severity, or even the nature, of the corneal and the conjunctival involvement. The lesions fell naturally into two groups: (1) conjunctival staining or precipitation of pigment and (2) corneal staining or precipitation of pigment. With the severest corneal involvement observed designated as ++++ and the severest conjunctival involvement as +++++, all the employees sent in for examination were classified by comparison with these standards. This classification having been completed, the patients were regrouped in accordance with the grading of the severity, extent and activity of the lesions. The original classification was completed in December 1943, with subsequent changes in ratings and transferral within the groups, as indicated in figure 1. A study of this chart demonstrates clearly that the length of employment, and inferentially the duration of exposure, is the most constant factor in determining the degree of injury. While in general it may be said that the severe ocular lesions have developed in persons employed five years or longer, the converse is not necessarily true. We feel that the explanation of this paradox lies not in individual sensitivity to the chemical but, more probably, in fortuitous circumstances, which prevented exposure comparable to the time of employment.

Since all the employees presented in the conjunctiva or the cornea more or less evidence of exposure to the chemical, only representative cases of each type will be described.

CASE 8 (presenting the severest corneal damage) —The patient, first observed in August 1943, had been working with hydroquinone for thirteen years. Six months previously, because of visual difficulties, he had been transferred from the plant. His corrected vision was 20/20 in each eye until 1942, when loss of acuity was first observed. The visual rating at this time was 20/30 in the right eye and 20/40 in the left eye. On examination in 1943 the acuity was as follows: O D 20/70, +2.50 C -5.00, axis 75 = 20/25, O S 20/400, +2.50, axis 110 = 20/25.

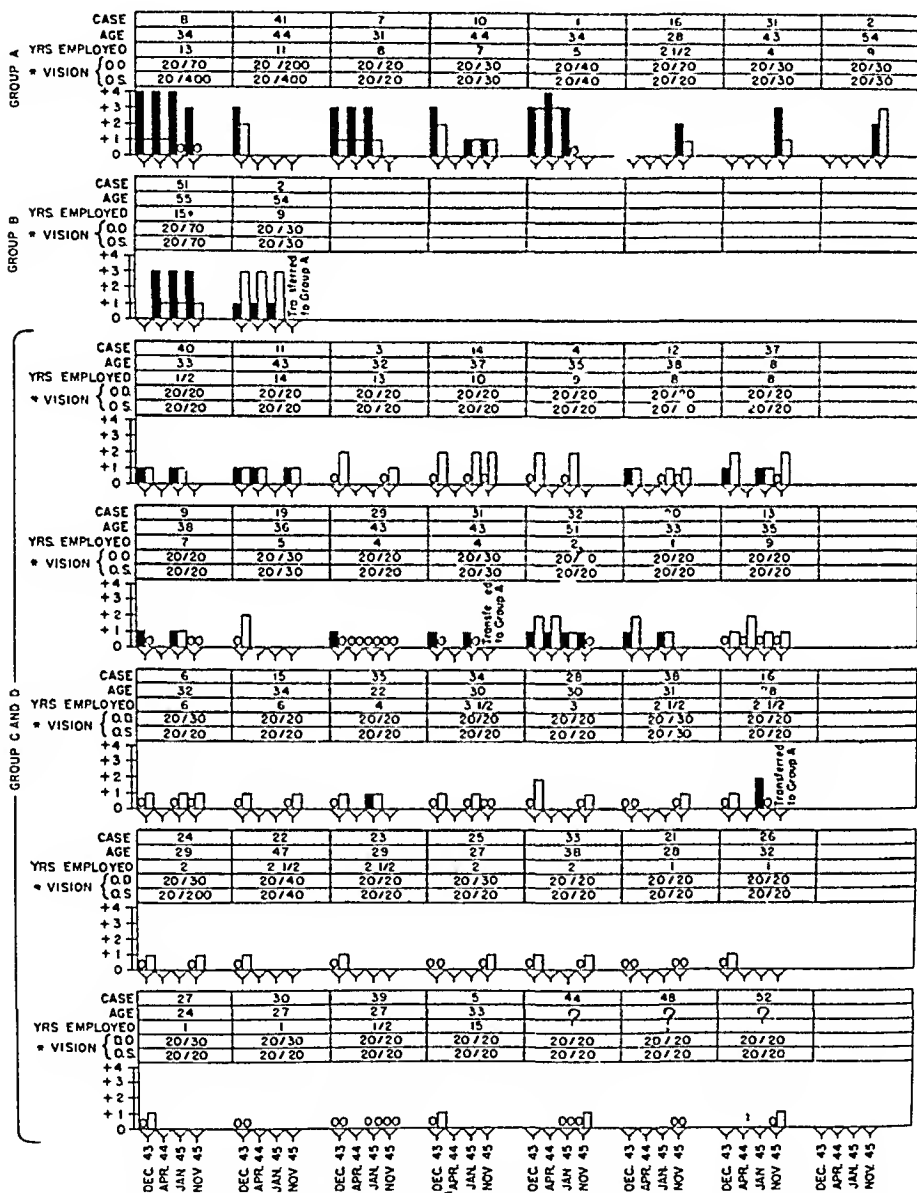


Fig 1—Classification of patients with corneal and conjunctival pigmentation engaged in the manufacture of hydroquinone, according to the severity of the lesion and the length of employment

The asterisks denote corrected vision, black areas, corneal involvement, clear areas, conjunctival involvement, and O, no change

Attention is called to the high cylinders. With the slit lamp, the following features were observed in equal degree in each eye. No gross conjunctival staining was observed near the limbus. Fine, discrete, brownish granules were observed at the limbus in the interpalpebral zone with high magnification. In the superficial layers of the conjunctiva on both the nasal and the temporal side were noted fine, glasslike spherules, somewhat similar to the small inclusion cysts seen in cases of chronic conjunctival irritation but differing in that they seemed to overlie and follow the course of the superficial veins. These cysts also were observed only in the interpalpebral zone. In the superficial layers of the cornea, just under or above Bowman's membrane, were many fine, grayish, translucent and highly refractile dots. These gave an irregular "beaten silver" sheen to the entire cornea. Many fine wrinkles, vertical in distribution, were observed in Descemet's membrane in each eye (fig 2). The cornea did not stain with fluorescein. There was definite hypesthesia. The terminal corneal nerve filaments appeared slightly larger than usual. The last examination, in November 1945, showed the same



Fig 2 (case 8) —Severest degree of damage to the cornea in a patient of group A

corneal picture as that originally described. The refractive error had not changed. There was no photophobia or staining of the conjunctiva. It is assumed that the corneal process is arrested, but the development of keratoconus remains a possibility.

CASE 41 —The patient had worked with hydroquinone for eleven years. Staining had been present for eight years. Visual failure had been observed for four years. The lesions were of identical character in the two eyes. Examination with the low power of the slit lamp revealed a peculiar band-shaped pigmentation of the temporal and nasal portions of the bulbar conjunctiva and of the cornea. This pigmentation was dark greenish brown, most intense on the nasal half of the cornea. The distribution of the lesions in the conjunctiva and the cornea was sharply limited to the exposed interpalpebral zone. On more critical examination with the higher power, two types of pigmentation were noted. First, in the cornea near the limbus, in fact, continuous with the limbus on the temporal side but with



a small, clear zone approximately 0.5 mm wide between the limbus and the pigment on the nasal side, were observed many fine, dark brown granules. Similar granules were seen in the conjunctiva. Second, a greenish yellow, homogeneous stain permeated the entire anterior layers of the cornea over the area delineated by the margins of the lids. In the more densely staining area, particularly in the right eye on the nasal side, were several small craters. In these areas it would appear that Bowman's membrane had been invaded. Lying beneath the epithelium, small scarred areas were seen with the narrow beam. These areas of scarring were of various shapes, but were usually a grayish white. They were sometimes confluent and branching. Deeper opacities were seen immediately beneath Bowman's membrane. These were semi-transparent and were obviously in the more superficial layers of the stroma. They probably represented edema of these portions of the cornea. The posterior portions of the corneal stroma were clear except that there were numerous vertical wrinkles of Descemet's membrane. The best vision in this case was 20/50 in the right eye and 20/60 in the left eye.

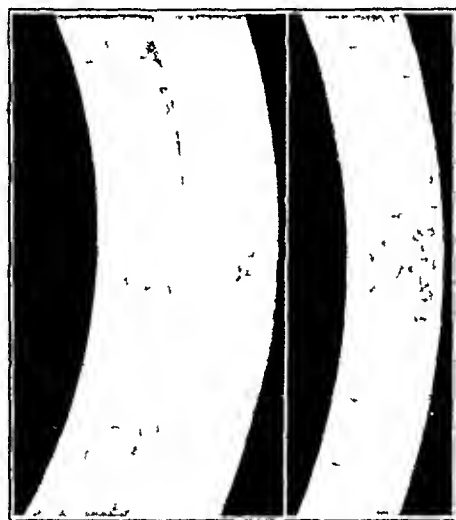


Fig 3 (case 1) —Severest degree of involvement of the cornea in another patient in group A

These men (cases 8 and 41), with 3 other persons (cases 7, 10 and 1, fig 3) were placed in group A. Subsequently, patients 16, 31 and 2 were transferred to this group. All persons in this group showed in approximately equal degree the lesions described in cases 8 and 41. Transferral to group A was considered as making mandatory immediate removal from the plant, a recommendation immediately complied with by the company.

In group B were placed those persons with corneal involvement so severe that the necessity of transfer, working conditions remaining the same, is to be anticipated. Case 2 (fig 4) illustrates this segment of the total work group.

CASE 2—The patient showed such progressive involvement in the examination in November 1945 that his transfer was recommended. When he was first seen in January 1944, the conjunctiva in the interpalpebral fissures showed staining. In this area it appeared thickened, almost gelatinous in structure, with embedded brownish green, granular patches standing out in relief. There was no surrounding inflammatory reaction. With the higher power of the slit lamp these granular patches were found to be made up of globules or granules of various sizes, from the barely perceptible to those having a diameter of 1 mm or more. They varied in color from very dark brown to light yellow. In the periphery of the cornea, with a clear margin intervening, was a belt of superficially deposited minute

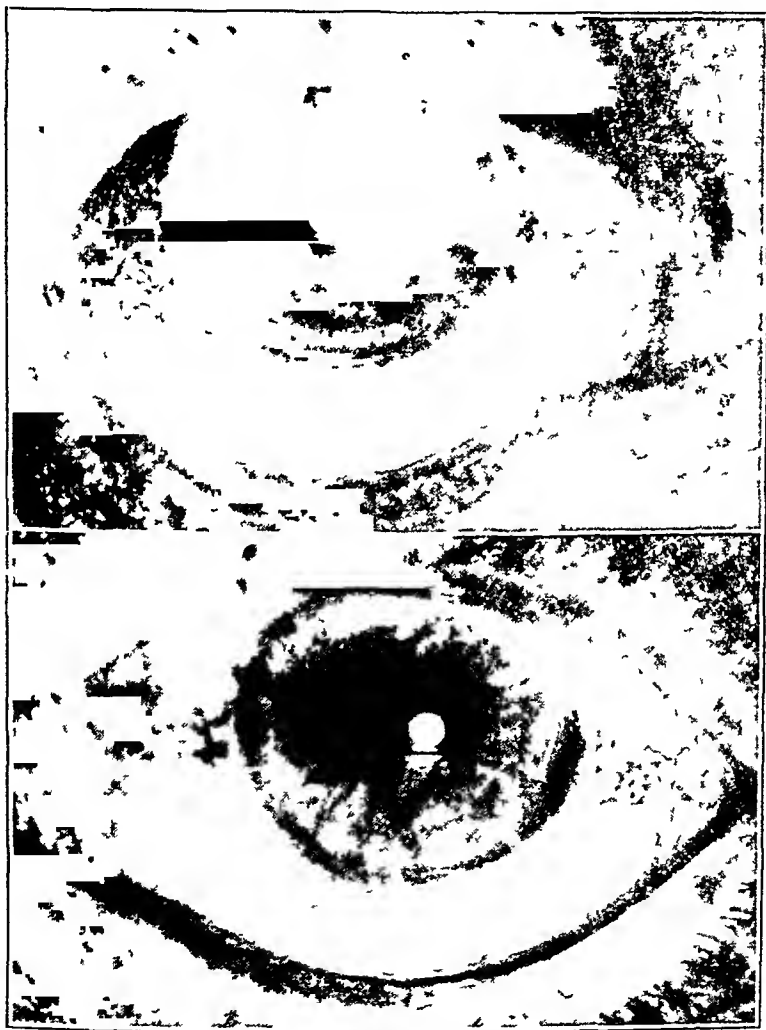


Fig. 4 (case 2) —Appearance of the eyes in a patient of group B, showing corneal involvement

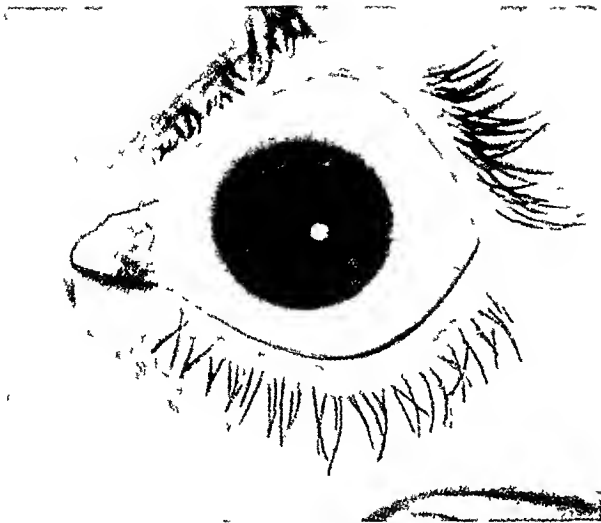
granules of brownish pigment, resembling except in color the ordinary arcus senilis. It was suggested that possibly this was a fat-soluble material which had become fixed in the fat of the arcus. While the man had no subjective complaints, on account of the degree of staining and the hypesthesia, he was placed in group B, with workers the necessity of whose transfer is anticipated. In November 1945 the absence of inflammatory signs was again noted. The diffuse staining of the conjunctiva was minimal, but the dark brown globules, previously observed to have been plentiful, had apparently increased in size and number. In the inter-

palpebral fissure of the right eye the precipitated pigment extended well over into the cornea in the area usually occupied by an arcus senilis. In addition to the definite granules of pigment in this area, a small area of intense homogeneous pigmentation was observed. In the right eye just below the pupillary area, superficially placed in the stroma of the cornea, was a horizontal white line with one vertical line extending inferiorly on the left side, the scar resembling a reversed and inverted letter *L*. The left eye showed conjunctival pigmentation without corneal changes.



Fig 5—*A* (case 14), eye of patient in group C, *B* (case 9), eye of patient in group D

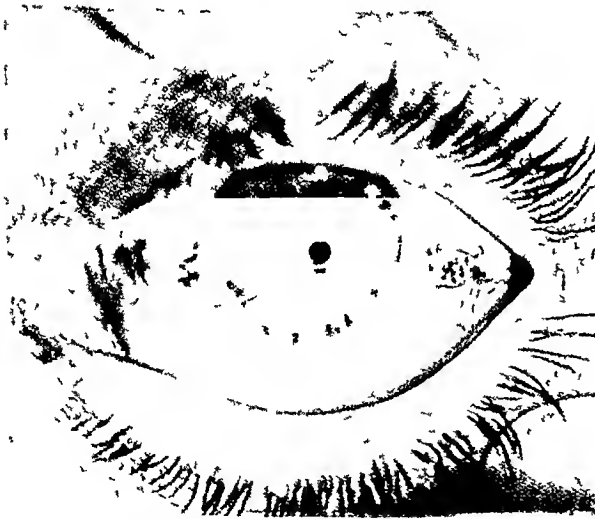
Group C included those men with slight involvement of both the cornea and the conjunctiva, as evidenced by scattered small globules in the conjunctiva with roughening of the corneal epithelium and slight hypesthesia (case 14, fig 5 *A*). In group D were placed those workers with only barely perceptible involvement, as evidenced by the faint sepia stain, without definite deposition of pigment in the conjunctiva (case 9, fig 5 *B*). Groups C and D are of interest only in demonstrating



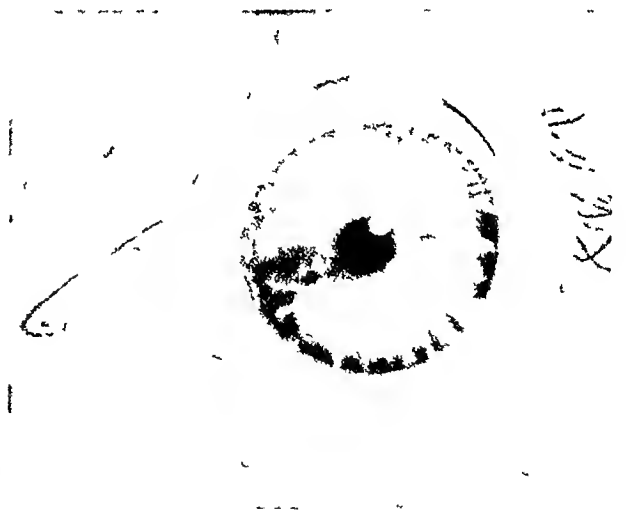
Earliest stage of conjunctival staining Note horizontal "band" distribution in interpalpebral zone No corneal stain



Moderately advanced conjunctival staining Note diffuse distribution of pigment and clear margin at periphery of cornea



Advanced conjunctival stain with globular distribution of pigment



Marked corneal pigmentation Note relatively slight conjunctival staining



how the lesion develops. All workers who had been employed for less than five years, as well as approximately 50 per cent of those employed for longer periods, fell in groups C and D.

One may well speculate at this time on the sequence of events which leads up to the final disability demonstrated by the 8 cases in group A.

#### MANNER IN WHICH INJURIES ARE INCURRED, SEQUENCE OF DEVELOPMENT OF LESIONS

Development of the lesions as reconstructed from the observations over the two year period would seem to be somewhat as follows:

A man in the early thirties comes into the plant and is trained to work in rotation in any of a half-dozen stations. After a two year interval a brownish tinge against the normally white sclera in the interpalpebral portions is noticeable. When examined with the slit lamp, the conjunctiva in these areas may appear slightly dried and have attached, irregularly and rather firmly to the surface, a white, frothy, foamlike deposit. The deeper portions of the conjunctiva in the same interval assume the light brownish sepia stain. No true microscopic deposition of pigment in definite granules or globules is visible. The cornea remains clear (plate 1, upper left).

After another two or three year interval the conjunctiva appears more thickened and drier, and, in addition to the superficially placed white flecks and sepia stain, small, discrete, dark brown granules or globular precipitates are observed in the deeper structures. Some migration of pigment, from the limbus into the cornea, can now be observed (plate 1, upper right).

After five or more years of exposure a definite increase is noted in the size, number and spread of both the granules and the extent of staining. The cornea has now become gravely involved (plate 1 lower left).

The final stage is seen in case 10 (plate 1 lower right). Vision has become seriously reduced. The patient has been removed from contact with the chemical. The conjunctival staining has cleared, as it apparently does in time. The corneal staining decreases but permanent damage is done to the cornea, resulting in increased opacity, increase in astigmatism, possibly thinning and keratoconus.

The fifth stage may well be opacity sufficient to necessitate corneal transplantation; the possibility of dyskeratosis, Bowen's disease or epithelioma must be kept in mind.

It will have been observed that in all these cases the chief peculiarity is the limitation of the pigmentation regardless of its amount and intensity to that portion of the conjunctiva and cornea within the

interpalpebral fissures. This is the feature which apparently differentiates cases of this condition from others in the scattered case reports of ocular lesions developing after exposure to aniline or its derivatives. That this staining penetrates deeply is proved by a biopsy section of the conjunctiva in case 16 (plate 2), in which the pigment is seen deposited as small granules in the superficial epithelium and as larger granules in the basal epithelial cells. It will be noted that in this section in the proximal portion of the large basal cells are small, finely granular, dark brown deposits, seemingly definitely intracellular. Beneath this, in the subepithelial substance, is a larger, globular, lightly staining, homogeneous mass, poorly defined, with no surrounding inflammatory reaction. Scattered diffusely in the subepithelial spaces, and generally without pattern, are smaller aggregations of pigment. The lighter-staining areas may also be filled with tissue partially saturated with the chemical.



Fig 6 (case 7) —Abrasion of the superficial epithelium of the cornea by dust particles in a hydroquinone plant

The question arises as to how the chemical finds its way into these areas and why the staining and precipitation are limited to the exposed interpalpebral portions of the cornea and conjunctiva. Possibly the first break in the defensive barrier is the purely mechanical action of the dust particles striking and abrading the superficial epithelium, as shown in case 7 (fig 6). According to Cogan's<sup>4</sup> work on corneal permeability, there are in the cornea, and presumably in the conjunctiva, a barrier to water-soluble chemicals in the epithelium and a second barrier to fat-soluble substances in the stroma. Since quinone is both water and fat soluble, these barriers do not afford sufficient

4 Cogan, D. J., Hirsch, E. O., and Kinsey, V. E. The Cornea. VI. Permeability Characteristics of the Excised Cornea, *Arch. Ophth.* **31**: 408 (May) 1944



Photomicrograph from biopsy specimen of conjunctiva, X 300  
 Note concentration of pigment in basilar epithelial layer



Photomicrograph from biopsy specimen of conjunctiva, X 1000  
 Note large globules of pigment in basilar cells proximate  
 to basement membrane and diffuse intracellular distribution  
 of finer pigment granules.





defense The pattern of deposition in the proximal portion of the basal cells suggests that these cells have an affinity for the chemical and that until saturated they act as a barrier I have no explanation for the appearance of the larger subepithelial globules unless it is that the chemical in solution becomes collected, perhaps by surface attraction, into sufficient critical masses in certain intercellular spaces to acquire a different oxidation-reduction potential with relation to this tissue and to become differentiated into these globules On the basis of such a theory, the relatively undifferentiated sepia-staining tissue might be assumed to be holding the material in unsaturated combination with body fluids

Since the fat content of the corneal epithelium forms 10 per cent of its dry weight,<sup>5</sup> as compared with 1 per cent of the stroma, the preference of the chemical for this tissue is understandable Dr David Cogan, who on one occasion studied these cases with me, in a personal communication draws the following tentative conclusions concerning the previously described lesions

The changes seen in the aforescribed eyes would appear to be of two types (1) deposition of pigment in the conjunctiva and cornea, and (2) opacification of the superficial portion of the cornea

The deposit of pigment occurs in the form of spherules of various sizes, is most prominent in the eyes of older patients and is to be observed in regions which normally contain fat, as, for example, in the palpebral portion of the episclera and in the arcus senilis of the cornea The opacification of the superficial portion of the cornea involves the palpebral fissure only, is most intense in the pupillary area and, while it affects both the older and the younger workers, is the presenting feature of the younger patients who have little deposition of pigment This opacification is accompanied with folds on the posterior surface of the cornea This superficial change in the cornea, and not the presence of deposits of pigment, is what causes the eye to be irritable The inflammatory response varies from photophobia to frank corneal ulceration The appearance of these superficial changes in the corneas is similar to that induced with formaldehyde vapor, and the clinical course is presumably similar, that is, small erosions recur as a result of the devitalized tissue

How the pigmented spherules get into subepithelial tissue may be variously judged It is suggested that the fat-soluble quinone is absorbed through the epithelium, where it is reduced partially, and, becoming less fat soluble, comes out of solution It would be interesting if those crystals which are frequently seen overlying the spherules are the crystalline form of this product In any case, the presence of these pigmented spherules apparently is nontoxic, and there is no evidence of their removal by the blood stream since they do not accumulate around the blood vessels

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<sup>5</sup> Krause, A C Biochemistry of the Eye, Baltimore, Johns Hopkins Press 1934

Hydroquinone is said to oxidize rapidly to paraquinone, a reaction which may be occurring in the air of the plant at all times. The oxidation is said to be accelerated in an alkaline medium and under certain conditions of moisture and heat. Velhagen<sup>5</sup> observed that if he placed a crystal of hydroquinone on filter paper previously saturated with the alkaline tears, a brownish stain developed very rapidly. He thus reasoned that small crystals of hydroquinone came in contact with the cornea and were there changed to paraquinone, which has the dark brown color. He also assumed that the lowering of the threshold for pain, which in itself is due to the chemical, permits, in turn, a greater exposure to this harmful agent without discomfort, thus setting up a vicious circle. The corneal sensitivity was tested in the 40 men whom my associates and I examined, and we concur in the observation that the loss of sensation is proportional to the degree of staining of the cornea.

Two of our patients (cases 8 and 41) have been hospitalized and subjected to exhaustive tests. Urinalysis and studies of the blood have been performed repeatedly on all persons employed in the plant. No suggestion of systemic intoxication with the drug, which after all is relatively harmless, has been observed. As a matter of record, 12 Gm was ingested in 1 instance, without fatality.<sup>6</sup> In this case the urine gave a positive reaction for phenol for only three days after absorption of the drug, so that a positive reaction for phenol in our cases, with what must have been minimal absorption, was hardly to be expected. It is the consensus that the absorption is purely local, probably an interaction with the tissues of a chemical which is both water and fat soluble, in an alkaline medium (tears), aided by the mechanical action of the blinking lids.

Assuming that the mechanism of the deposition of the pigment is explained, at least in part, by its affinity for these tissues with a high fat content, one still has to explain the limitation of the staining and precipitation of pigment to the interpalpebral zone. The appearance of the cornea with the slit lamp in the 4 patients with ochronosis described by Smith<sup>7</sup> more closely parallels that of the cornea and conjunctiva in the cases under discussion than any other phenomenon described in the literature. The ocular picture is described as consisting of deposition within the interpalpebral fissures of a band of brownish pigment, extending from the temporal portion of the conjunctiva across the cornea and into the nasal conjunctiva. Fine, brownish yellow spots are seen posterior to the vessels in the conjunctival limbus in the sub-

6 Remond, A., and Colombies, H. Intoxication par l'hydroquinone, *Ann de med leg* 7 79, 1927.

7 Smith, J. W. Ochronosis of the Sclera and Cornea Complicating Alkaptonuria, *J. A. M. A.* 120 1282 (Dec 19) 1942.

stance of the cornea. These brownish granules in the cornea are seen in a zone near the limbus and in 1 case were so numerous as to be visible without magnification. These pigment particles are described as "some of pinehead size and others as small as powdergrains." They are located in the more superficial layers of the cornea, probably just below Bowman's membrane, some appearing like droplets, a double convex reflection may be seen, suggesting that some of the pigment spots have a different refractive index, some lie deep, but most of the pigmented areas are in the superficial layers of the cornea.

It has been said that in cases of ocular ochronosis the alkaptonuric patient cannot effect the complete catabolism of the tyrosine and phenylalanine contained in the proteins of the food and tissues, so that an intermediate product, homogentisic acid (2,5-dihydroxyphenylacetic acid, or hydroquinone-acetic acid), remains. Homogentisic acid shares with similar aromatic compounds the property of blackening on oxidation, which explains the dark color of the urine. Pick<sup>8</sup> suggested that in ochronosis through the oxidative ferment tyrosinase the phenol substances in the exogenous group and the homogentisic acid molecule in the endogenous group are changed into melanin pigments which are deposited in the tissues. This is in accord with the belief expressed by Abderhalden and Guggenheim<sup>9</sup> that an accumulation in the human organism of excessive and abnormal amounts of substances possessing the oxyphenol groups leads to the production of melanin pigments by action of ferments.

We assume, then, that the chemical hydroquinone, or some modification thereof, goes into solution in an alkaline aqueous medium (tears). Since the substance is fat soluble, it is also combined in the cornea and conjunctiva by some interaction with fat in the normal reservoirs and with the fat present as a result of insult and injury to the cornea. This "bound" material in the interpalpebral fissure, being exposed both to light and to the specific effect of the intracellular oxidase, which acts in the presence of radiant energy, undergoes modification in structure similar to the intermediate products of hydrocarbon metabolism in ochronosis, producing a melanin-like material deposited in these fat reservoirs.

This assumption, it must be admitted, has no experimental backing. Attempts to reproduce the pigmentation were unsuccessful in rabbits, in that exposure to fumes and solutions of such strength as not to produce

8 Pick, L. Ueber die Ochronose, *Berl klin Wchnschr* 43:478, 1906.

9 Abderhalden, E., and Guggenheim, M. Versuche über die Wirkung der Tyrosinase aus *Russula delica* auf Tyrosin, tyrosinhaltige Polypeptide und einige andere Verbindungen unter verschiedenen Bedingungen. *Ztschr f physiol Chem* 54:331, 1908.

more specific inflammatory reaction would not produce the lesion, possibly because the albino rabbit does not carry in its cell the oxidizing enzyme which is capable of reacting on this substance

#### TREATMENT

The problem of treatment may be disposed of by the mere statement that there is no really effective therapy other than prevention. Possibly some of these patients may later be candidates for contact lenses or keratoplasty.

#### PROGNOSIS

The prognosis in our cases may be further judged by the statement of Lewin and Guillery,<sup>10</sup> that the cause of corneal lesions in workers engaged in certain dyeing procedures is the presence of quinones in the vapors. These authors stated that these quinones precipitate on the cornea and conjunctiva and cause injury by contamination of these areas by the worker's rubbing the affected parts with the fingers and hands. This corrosive effect on the cornea is paralleled by pigmentation of the cornea. By continued repetition of this injury, the epithelium of the cornea may be completely undermined, and penetrating sepia brown pigmentation and turbidity of the parenchyma, a serious reduction of the visual acuity and symptoms of severe keratoconjunctivitis may be produced. In some instances distinct vesicular ulcers of the cornea may result. According to Lewin and Guillery, involvement of the cornea improves on discontinuation of the exposure and with ordinary treatment such as that used for keratitis, within several months to one year. The epithelium regenerates, the pigmentation decreases, and the visual acuity is improved.

I do not believe that the facts justify any such sanguine attitude toward the ultimate outcome in the cases we have described. Keratoconus and ulceration are possible complications. Patient 8 shows some evidence of keratoconus, and in Velhagen's second case there was a history of ulceration. With the slit lamp we noted enlargement of the terminal nerve filaments in several cases. The deleterious effects of phenol, dinitrophenol and other such chemicals on the peripheral nerve mechanism are well known, and it is probable that, as a result of these changes trophic disturbances, which are notoriously resistant to the reparative measures of the body, may have developed in the cornea. Prolonged exposure has produced corneal dystrophy, dyskeratosis and perhaps keratoconus. While the drug is of minimal toxicity and does not belong to the carcinogenic group, some of the lesions we have seen resemble

10 Lewin, L., and Guillery, H. *Die Wirkungen von Arzneimitteln und Giften auf das Auge*, in *Handbuch für die gesamte ärztliche Praxis*, Berlin, A. Hirschwald, vol. 1, p. 728, cited in letter from chief industrial toxicologist, United States Public Health Service.

clinically Bowen's disease. The possibility of the later development of a frank malignant growth in some cases must be kept in mind.

#### PREVENTION

The question of prevention of further injury becomes a matter of improved housekeeping, better ventilation, personal hygiene and, possibly, the use of goggles. Further injury in specific cases is being avoided by removal from the vicinity of the plant of those persons whose corneas show early staining. In this connection, it is well to note that once the cornea is extensively damaged and the terminal nerve filaments are injured, the disappearance of the stain does not necessarily connote improvement. Case 8 is an example of this corneal damage, which persists or increases after the stain has disappeared. In all cases the lesions have been slow to develop, and routine examination with the slit lamp should determine when tolerance has been reached.

#### SUMMARY AND CONCLUSIONS

Observations are presented on a group of workers employed in the manufacture of quinone and hydroquinone in whom certain characteristic lesions of the cornea and conjunctiva have developed.

These lesions consist of (1) a variable degree of pigmentation of the interpalpebral portions of the conjunctiva and cornea, proportional to length of employment and to age, and (2) corneal changes, which may be due in part to the corrosive action of the chemical, but which, in view of its obvious failure to stimulate inflammatory reaction in the conjunctiva, are more probably the result of migration or penetration of the chemical into the corneal structure, in the same manner as the invasion of the conjunctiva occurs, with a variation in response due to the peculiarities of the corneal structure. These changes consist in pitting and erosion of the corneal surface, thinning of the cornea, development of irregular pigmented or staining areas (which may or may not simulate Stahl's lines), wrinkling or modification of Descemet's membrane and, possibly, keratoconus. The changes are apparently reversible up to a certain point in that conjunctival staining may disappear. The corneal stain is more permanent.

Since only those portions of the conjunctiva and cornea in the interpalpebral space take the stain, it is assumed that some reaction takes place between chemical and tissue which is possible because of a peculiarity in structure limited to this area, or of the additional effect of light on the chemical and tissue. The possibility is suggested that this change in the limited area may be somewhat analogous to the deposition of pigment in the interpalpebral fissures associated with ochronosis.

Since the lesion could not be produced in rabbits, it must be assumed that in man some additional, and as yet unknown, factor must exist, or that the rabbits, being albinos, did not possess the specific intracellular oxidase necessary to the formation of this melanin-like substance. The chemical is relatively harmless so far as its immediate effects can be determined.

Prolonged exposure has produced corneal dystrophy and dyskeratosis, and perhaps, keratoconus. While the chemical is said not to belong to the carcinogenic group, some of the lesions resemble Bowen's disease. The development of a frank malignant growth is not beyond the bounds of probability.

## Clinical Notes

### BETA RAY RADIUM APPLICATOR FOR OCULAR USE

#### Preliminary Report

CHARLES E. ILIFF, M.D.

BALTIMORE

THE VALUE of beta irradiation in the treatment of certain ocular lesions is well recognized but the difficulty in obtaining the radon for the Burnam applicator has greatly limited its use. Accordingly, a beta ray radium applicator was designed which would as nearly approach as possible the performance of the Burnam applicator. In order to understand the use of this radium applicator the differences between radon and radium must be appreciated and the construction of the applicator understood.

Radon is a gas, a breakdown product of radium, and one hundred thousand times as active weight for weight, as the radium in the form of salt. It is thus possible to concentrate in a very small space an extremely high potential of radioactivity. The breakdown rate of the radon is extremely rapid, as the half transformation time is 3.83 days. In the Burnam applicator a radon seed of 5 mm diameter, containing 200 to 500 millicuries of radon, is used. Beta and gamma rays are emitted from the radon as from an apparent point source at the center of the seed. The seed is placed in a brass cylinder with walls 2 mm thick and with an open window, 4 mm in diameter, at one end. Through this window beta rays pass unfiltered. The gamma rays pass out from the seed in all directions, as they are only slightly filtered by the brass cylinder.

#### THE APPLICATOR

In the construction of the radium applicator here reported, the plaque form was found to be the most satisfactory. The plaque is really a small portable radon plant, the radon being given off from the radium salt contained therein. The radium must be spread in a layer so thin that it does not in itself act as an appreciable filter of the beta rays, and thus it is not impossible to use more than 50 mg in an ocular applicator of convenient size. The radon is held in the interstices of the radium salt, and the beta rays are given off as a surface fire, rather than as the point source fire emitted from a radon bulb. For this reason, any radium ocular applicator would deliver per unit area only one-quarter to one-fifth the amount of beta radiation delivered by a radon bulb of equivalent strength. This extremely important point limits the use of the plaque applicator to those conditions which can be treated with surface fire.

From the Wilmer Ophthalmologic Institute of the Johns Hopkins Hospital and University



The beta rays from the radium applicator are filtered both by the radium salt and by the 0.1 mm "monel" metal face plate, so that the delivered output is 30 milliequivalents. This must be contrasted with the 200 to 500 millicurie content of the Burnam radon applicator.

The half-transformation time of radium is over fifteen hundred years, so deterioration is not an important factor.

In summary, in the radon applicator, there is a point source of radiant energy ranging from 200 to 500 millicuries, with a very short half-transformation time. The radium applicator, on the other hand, has a low potential, a wide surface fire, rather than a point fire, and what might be termed an unlimited life expectancy.

In a previous communication<sup>1</sup> the use of the Burnam applicator was discussed in detail in the treatment of vernal conjunctivitis, tuberculous scleritis and small tumors of the anterior ocular segment and in the occlusion of vessels and the prevention of fibrous overgrowth. In the treatment of vernal conjunctivitis, tuberculous scleritis and tumors of the anterior segment, the fact that the radium applicator delivers a surface fire rather than a point source fire is not a disadvantage. However, it is not practical to treat a lesion the size of an individual vessel or a number of small vessels with surface fire, since the object of such treatment is to occlude the vessel itself by producing endarteritis, with as little damage as possible to the surrounding tissues. For this, the point source fire of the radon applicator is ideal, and the wide surface fire is not satisfactory.

A kidney-shaped applicator with a foot plate of concave scleral curvature was considered, but the technical difficulties in production of such an applicator overbalanced its possible advantages. Therefore, a rectangular applicator measuring 6 by 12 by 6 mm and containing 50 mg of radium salt was made. The sides and back are of silver and measure 1.0 and 3.0 mm, respectively, and the face plate is 0.1 mm of "monel" metal. A handle 28 cm in length is screwed into the back of the plaque (fig. 1). A ten minute treatment time is required to give a delivered contact dose of 4 gram seconds per unit area. A holder for the applicator is, therefore, important. The holder pictured in figure 2 consists of four brass bars with swivel joints, which can be moved in any direction to permit the application at the desired angle.

The ten minute application time in the treatment of lesions of the lid is associated with no particular discomfort or inconvenience. A lid speculum is necessary in the treatment of scleral lesions, and application of tetracaine ointment five minutes before the treatment greatly reduces the discomfort. The patient is placed in the treatment chair next a screen or wall, on which a mark can be made for the fixation of the eyes in the desired position. A time clock, such as that used by photographers, was found to be quite satisfactory. Ten minute applications, delivering doses of 4 gram seconds, can be repeated after an interval of one week, and again the second week, the total dose remaining well below the contact skin erythema dose of 18 gram seconds. Such a course of therapy could be repeated after an observation period of two to three

1 Iliff, C. E. Beta Irradiation in Ophthalmology, Arch Ophth 38 415 (Oct) 1947

weeks and at intervals as found necessary for the patient's improvement. In treatment of lesions smaller than the face plate of the applicator, 0.5 mm of sheet lead is found useful as protection to the surrounding tissue. The lead can be cut with scissors to any desired shape and

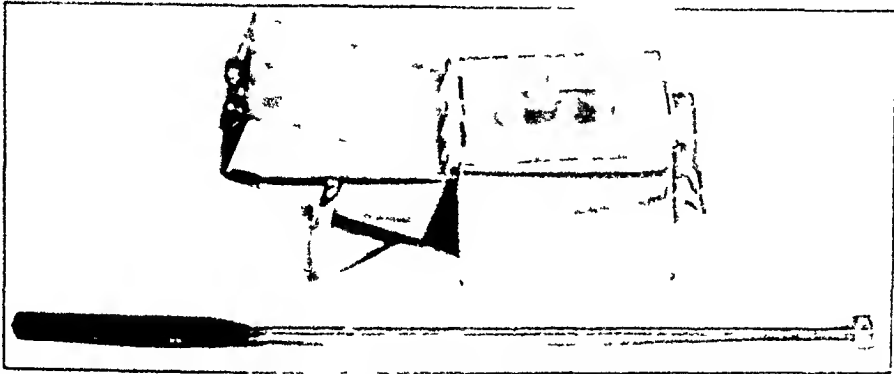


Fig 1—Radium applicator, with lead carrying case, manufactured by the Radium Chemical Company, Inc., New York

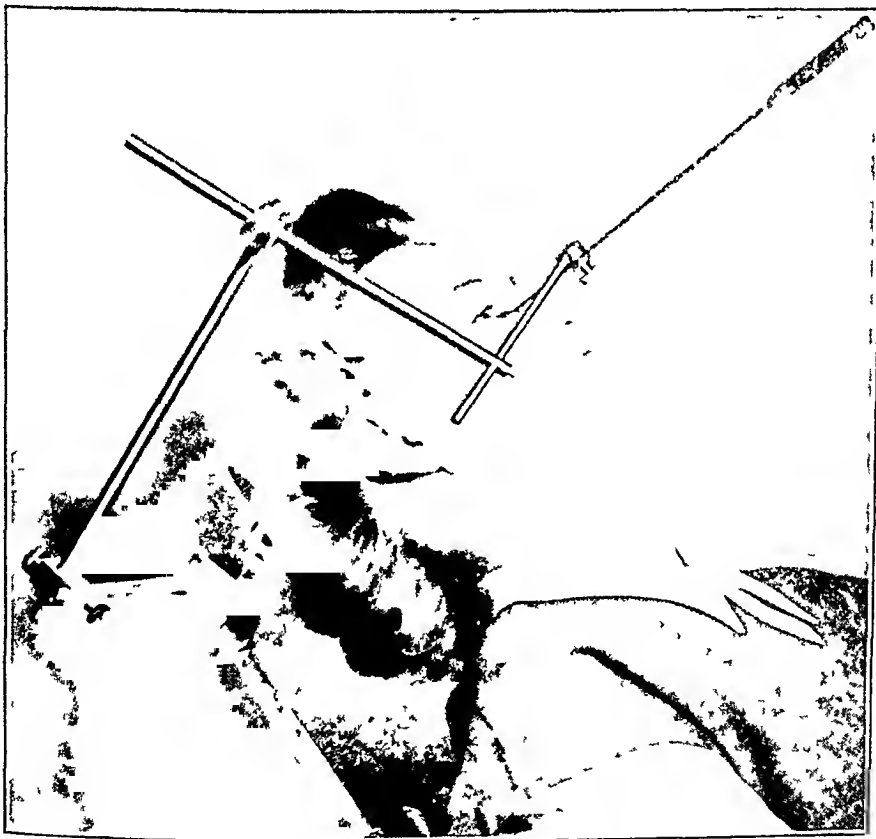


Fig 2—Holder for radium applicator, made by Mr. Albert Goebel, Wilmer Ophthalmological Institute. The applicator is shown in contact with the papilloma of the lid.

molded easily to fit the lesion. In some cases of papilloma or tumors of the lid, a cross fire technic and a total treatment time as high as thirty minutes at one period were employed.

## SAFETY FACTORS

The 28 cm handle on the plaque provides an adequate factor of safety for the operator. It is unwise for the physician to hold the lid during treatment or to handle the plaque itself. All the usual precautions for radium and roentgen therapy should be observed. The relation of outputs of beta and gamma rays in the radium applicator differs slightly from that in the radon applicator. However, the proportion of gamma rays is still well within the range of safety, and there is no danger of cataract formation if the operator observes the general rules for beta ray therapy presented in the previous communication.<sup>1</sup>

## SUMMARY

A beta ray radium applicator for ocular use is presented. The time of application is greatly increased, and its use as compared with that of the Burnam radon applicator is limited. Owing to the low potential and the surface fire, the use of the radium applicator is limited to treatment of vernal conjunctivitis, tuberculous sclerokeratitis and small tumors of the anterior segment and to the prevention of overgrowth of fibrous tissue. It is not useful in the occlusion of vessels. The instrument should be applied by means of a holder of some form. The usual precautions in using all radiation therapy should be observed. It is felt that the radium applicator, although it cannot duplicate the performance of the radon applicator, will fill a definite need as an addition to the instruments that are available to the ophthalmologist in the treatment of the aforementioned lesions.

12 West Read Street (1)

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OINTMENT ABSORBED THROUGH CORNEAL WOUND

## Report of a Case

DONALD K. BINDER, M.D.  
SCHENECTADY, N. Y.

That the instillation of ointment into the eye after a penetrating wound is not without danger is illustrated by the case reported here.

## REPORT OF CASE

C. P., aged 43, a machine operator was struck in the right eye with an unknown object while at work. He was treated at the first aid station of his employer where an ointment was instilled, the nature of which is not precisely known but which is believed to have been a sulfonamide preparation.

He was seen by me shortly thereafter, when I found that he had a small perforating linear wound just below the center of the cornea. The anterior chamber was formed, but there was injury to the lens with partial traumatic cataract. Within the anterior chamber there were two spherical yellowish globules, each approximately 1 mm. in diameter—one situated in the upper part of the limbus and the other in the limbal region at 9 o'clock. The nature of these foreign bodies was obscure. The patient was hospitalized, and roentgenographic study failed to reveal an intraocular foreign body. He made a good recovery, and the eye became white. However, the two globules coalesced, to form one. The globule was

apparently lighter than the aqueous fluid as it always sought the highest point in the anterior chamber, much as does the air bubble in a spirit level. If the patient stood up the globule would move to the upper part of the limbus (figure 1<sup>1</sup>), if he lay down on one side it would move to the opposite angle of the chamber, and if he was supine it would move to the center of the anterior chamber and interfere with his vision.

A colleague who had occasion to see the patient suggested that the foreign material might be ointment. He informed me that he had had a case in which ointment had entered the eye but eventually had disappeared. I therefore waited approximately six months to see whether this would happen.

I was also informed by the medical department of a leading pharmaceutical house that if ointment did enter the eye it would not be likely to form a globule but rather would produce a diffuse haziness since the usual ointment base has a melting point which is below the temperature of the aqueous fluid.



Position of the globule in the anterior chamber when the patient was standing

Through a keratome incision at the upper part of the limbus the foreign material was evacuated, and in the process its gelatinous nature was revealed. Unfortunately, the amount which could be saved was not sufficient for examination. A good recovery was made.

It is interesting to note that after the operation macular changes developed in the other eye, which reduced vision from 20/20 to 20/50, with no other pathologic alterations.

The almost routine use of ointment after intraocular operations by many surgeons and in many institutions with no report of any penetration into the anterior chamber would indicate that the possibility of this complication exists principally when there is a direct corneal wound. The mechanism of penetration, I presume, is some phenomenon of aspiration. A search of the literature of the past twenty years revealed that only 1 such case had been reported.<sup>4</sup> A foreign body deeply

<sup>1</sup> Dr E. Kellert, Ellis Hospital, Schenectady, N. Y., made the photograph.

<sup>2</sup> Personal communication to the author.

<sup>3</sup> Abbott Laboratories. Personal communication to the author.

<sup>4</sup> Tetz, H. M. Unusual Retrocorneal Phenomenon (Globule of Prontosil in Anterior Chamber), *Brit. M. J.* 1:665 (May 29) 1943.

embedded in the cornea was removed, with perforation and escape of the aqueous fluid. An ointment containing azosulfamide (disodium 4-sulfamidophenyl-2'-7'-acetylamino-1'-hydroxynaphthalene-3',6'-disulfonate) was instilled and entered the anterior chamber, where it remained. It was concluded that the entrance was due to the pressure of the bandage.<sup>4</sup>

#### SUMMARY AND CONCLUSION

A case is presented illustrating the entrance of ointment into the anterior chamber following a penetrating wound of the cornea. This ointment was not absorbed and necessitated removal.

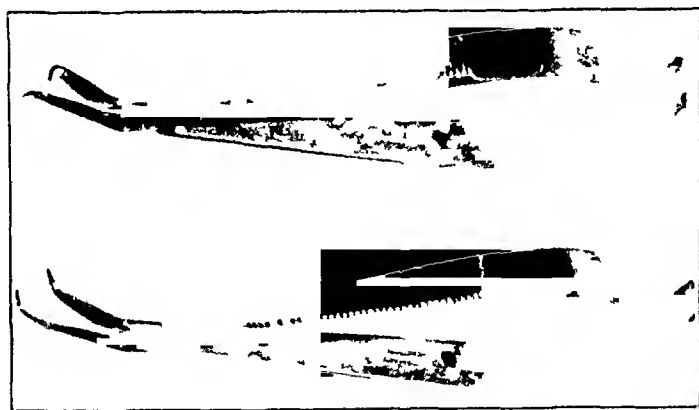
After perforating wounds of the cornea one should not use ointment in the eye.

102 Barrett Street (5)

#### IMPROVED SCISSORS FOR CORNEAL GRAFTING

HERBERT M. KATZIN, M.D.  
NEW YORK

The choice of round versus square corneal grafts for use in partial penetrating keratoplasty has been resolved by some authors in favor of the square type because of the facility of excision of the square graft with the straight-bladed scissors. I felt, however, that the ease of outlining a round graft and its superior cosmetic properties were worth consideration and devised a pair of scissors which were curved to the



Scissors for corneal grafting curved to the diameter of the round graft

diameter of the round graft. These scissors made the completion of the trephine incision much easier than it had been heretofore. The most recent model of these scissors is fashioned after Castroviejo's straight keratoplasty scissors. They are made up of right-handed and left-handed curves, so that the operator need not move his position from the

From the Corneal Research Laboratory, under the auspices of the Ayer Foundation.

head of the table, and in a 5, 6 or 7 mm diameter curve, depending on the size of the trephine used. They have been employed in many transplantations, both experimental and clinical, with entire satisfaction.

These scissors make it possible to perform the entire corneal section without danger of injury to the lens. The anterior chamber may be entered with a Wheeler knife, instead of trephining through the cornea, in cases in which the eye is soft, the chamber shallow or the cornea so opaque that the structures of the anterior segment cannot be seen.

1148 Fifth Avenue

# Abstracts from Current Literature

EDITED BY DR WILLIAM ZENTMAYER

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## Anatomy and Embryology

SURGICAL ANATOMY OF THE FACIAL NERVE WITH REFERENCE TO THE TECHNIQUE OF ORBICULARIS BLOCK (PALPEBRAL AKINESIA)  
M KLEIN, Brit J Ophth 30 668 (Nov) 1946

Review of the literature on facial akinesia shows three approaches the terminal branches, the main trunk at the stylomastoid foramen and the middle portion of the course of the nerve near the ramus of the mandible. Dissections have shown that the surface marking of the middle portion of the facial nerve corresponds to a horizontal line drawn through the junction of the upper and the middle third of the distance between the zygoma and the angle of the mandible. The position of the nerve within the parotid gland is in a plane of cleavage between the two lobes of the gland, which may facilitate the spreading of the procaine into the nerve. The correct point for the injection, when the middle portion of the course of the facial nerve is used for palpebral akinesia, lies below the condylar process, at the junction of the upper and the middle third of the distance between the zygomatic arch and the angle of the mandible.

W ZENTMAYER

## Conjunctiva

PEMPHIGUS CONJUNCTIVAE F W NEWELL and J S GRELTHAM,  
Am J Ophth 29 1426 (Nov) 1946

Newell and Greltham define, describe and briefly review the literature of pemphigus. They report 3 cases, 1 of which was complicated by bilateral uveitis with complicated cataract.

W S REESE

THE CYTOLOGY OF CONJUNCTIVAL EXUDATES P THYGESON, Am J Ophth 29 1499 (Dec) 1946

Thygeson studied smears and conjunctival scrapings in 2,000 cases of conjunctivitis of diverse causes. He found that variations in leukocytic reactions and epithelial changes were sufficiently great to have diagnostic value, and he recommends that a statement on the cytologic character be a part of every laboratory report on conjunctival scrapings or exudates.

W S REESE

SEED GRAFTING OF THE CONJUNCTIVA IN THE TREATMENT OF SYMBLEPHARON A HAGEDOORN, Am J Ophth 29 1568 (Dec) 1946

Hagedoorn describes a case of total symblepharon of the inferior eyelid treated by means of small "seed" grafts from the conjunctiva of the same eye, in combination with a (Stent's) mold. Light perception

and accurate projection were obtained. A colored contact glass was inserted. Both subjective and objective results were good.

W. S. REESE

### Congenital Anomalies

BIATERAL PARTIAL COLOBOMA OF THE OPTIC NERVE. J. A. MAGNUS, *Brit J Ophthalm* 30: 602 (Nov.) 1946

The right eye showed a disk at least twice the normal size, deeply cupped below and to the nasal side. The upper branches of the central retinal vessels emerged a little above the center of the disk, whereas the lower branches emerged at the circumference of the disk and bent sharply around the edges. The disk in the left eye was of equal size with the disk in the right eye. The upper branches of the retinal vessels entered by the central part of the disk, whereas the other retinal vessels entered along the lower edge of the disk. Some of them were branches of the short ciliary arteries. There was slight cupping below and to the nasal side. The visual field of each eye showed a deep depression above, caused by a nerve fiber bundle scotoma, whereas the lower half of the field was normal. These field defects corresponded to the deeply cupped parts of the disk.

W. ZENTMAYER

### Experimental Pathology

CHEMICAL BURNS OF THE RABBIT CORNEA. C. P. CARPENTER and H. F. SMYTH JR., *Am J Ophthalm* 29: 1363 (Nov.) 1946

Carpenter and Smyth found from experiments on rabbits that alkaline molecules become bound to the epithelial cells of the cornea and are not removed by prolonged washing, but that the alkali is slowly liberated, thus resulting in a progressive burn. Attempts to neutralize this alkali were not successful, and denudation of the cornea failed to demonstrate its effectiveness, owing apparently to species differences in the rate of epithelial regeneration.

W. S. REESE

### General

DEPOSITION OF MERCURY IN THE EYE. I. ABRAMOWICZ, *Brit J Ophthalm* 30: 696 (Nov.) 1946

A woman aged 57 had used an ointment containing ammoniated mercury on the lids continuously since she was 16 years old for the relief and prevention of blepharitis. For the past ten years the skin of the lids had been bluish gray, and the conjunctiva was hyperemic. Biomicroscopic examination showed dark pigment granules in the bulbar conjunctiva, especially near the cornea, with preferential distribution around the perivascular spaces. In the periphery of the cornea in the region of Descemet's membrane occurred a discoloration, varying from greenish gray to bluish gray. A yellowish brown, lusterless opacity occupied the pupillary area of the lens just under the capsule.

W. ZENTMAYER



# STRANGE OCULAR COMPLICATION CAUSED BY SULFADIAZINE POISONING D PRADO, Arq brasil de oftal 8: 169 (Dec ) 1945

A man aged 24 was first examined in November 1944. The ocular condition had started in June of that year, after prolonged treatment with sulfadiazine. The initial ocular symptoms were severe conjunctival irritation, a sensation as of sand in the eye, slight photophobia and lacrimation, high fever, headache and a generalized rash. After three days the eyelids were closed by a conjunctival exudation. About five months later there were narrowing of the palpebral fissures, marked trichiasis, lacrimation and small subconjunctival hemorrhages in both eyes. The corneas were normal. An unusual finding was the presence of a symmetric symblepharon, with vertical bands in the internal and the external angle of both eyes. Depilation with the diathermic current was performed, with relief of the condition. The aspect of the conjunctivas, however, remained the same.

M E ALVARO

## General Diseases

# OCULAR MANIFESTATIONS OF AVITAMINOSIS R DE TOLEDO, Arq brasil de oftal 8 173 (Dec ) 1945

The author reviews the several ocular disturbances caused by avitaminosis. Xerosis and keratomalacia are due to lack of vitamin A. These ocular symptoms are characterized by loss of brilliance of the cornea and the presence of Bitot spots. They are not early symptoms, however, and are usually associated with other signs, such as night blindness and disturbances of the skin and glands. Experimental cataract in rats due to vitamin A deficiency has been observed. Blepharokeratoconjunctivitis, especially in children, has been known to respond promptly to treatment with vitamin A in numerous cases. Night blindness is also a well known sign of vitamin A deficiency. The most frequently observed avitaminoses of the B group are the superficial keratitides. Deficiencies due to the vitamin B complex seem to affect the optic nerve more severely than the other ocular tissues. Thiamine deficiency causes a noninflammatory neuritis without degeneration of the nerve fibers. Retrobulbar neuritis is also associated with deficiency of the vitamin B complex. Besides the oculomotor disturbances, such as isolated paralysis and paresis of certain extrinsic muscles, Wernicke's syndrome (superior hemorrhagic polioencephalitis) has also been attributed to a lack of thiamine. Ascorbic acid is useful in the medical treatment of cataract. Vitamin D is successfully used in cases of blepharitis, conjunctivitis, keratoconjunctivitis and myopia. Vitamin K preparations have been widely used in cases of ocular hemorrhages, and the tocopherols (vitamin E) have been stated to be useful in the treatment of parenchymatous keratitis and keratoconus.

M E ALVARO

## Glaucoma

# GLAUCOMA CAPSULARE H S GRADLE and H S SUGAR, Am J Ophth 30 12 (Jan ) 1947

Gradle and Sugar give a brief history of glaucoma capsulare, describe its zones of capsular exfoliation and differentiate it from simple glau-

coma They cite several cases to illustrate its clinical aspects and state that removal of the lens has no great effect on the ocular hypertension

W S REESE

INFLAMMATORY JUGULAR PHLEBOSTENOSIS AS THE CAUSE OF GLAUCOMA EXOGENICUM O MEYER, Brit J Ophth 30:682 (Nov) 1946

Glaucoma exogenicum has its cause outside of the eye in cases of chronic proliferative endophlebitis of the jugular veins Jugular endophlebitis has a narrowing effect on the lumen of the vein, which interferes with venous drainage of the head region Blockage of the proximal portion of the jugular vein produces an increase in venous pressure in all distal veins, including the episcleral veins, which drain the veins of Schlemm's canal The deciding factor in a normal drainage of the aqueous humor from the anterior chamber is the difference between the higher pressure in the anterior chamber and the lower pressure in the veins of Schlemm's canal and the episcleral veins If the venous pressure of the veins in Schlemm's canal and the episcleral veins equals or exceeds the intraocular pressure, the slope in pressure is eliminated and the drainage of the anterior chamber is stopped completely The treatment of exogenic glaucoma resolves itself into a recalibration of the jugular veins

W ZENTMAYER

### Hygiene, Sociology, Education and History

SOME HISTORICAL NOTES ON SPECTACLES AND ON BERYLLUS G TEN DOESSCHATE, Brit J Ophth 30:660 (Nov) 1946

It is generally held that Roger Bacon (1214-1294) was the first European scholar to mention the practical utility of lenses He, however, was anticipated by Robert Grosseteste (1175?-1253), who, so far as the author knows, was the first scholar in Western Europe to write on optics A third Englishman, John Peckham (1228-1294), is renowned for his work "Perspectiva communis"

Beryl is the name applied to the precious stone, including the emerald, the aquamarine and other transparent varieties known as "precious beryl," with certain coarse opaque varieties unfit for use as gems In Meyer's "Konversations-Lexicon," it is stated that the German word *Brille* is derived from *Berill*, the name of "transparent pieces of stone and glass" Curative powers were ascribed to *beryllus* It seems possible that when men first used spectacles they believed that improvement of visual acuity was caused by the pharmacologic power of the gem

W ZENTMAYER

### Injuries

CHEMICAL BURNS OF THE HUMAN CORNEA R S McLAUGHLIN, Am J Ophth 29:1355 (Nov) 1946

From a study of 500 cases, McLaughlin concludes that with chemical burns of the cornea immediate first aid followed by long flushing with water is of utmost importance and that denudation of the cornea is the treatment of choice

W S REESE

BLUE HALOES IN ATABRIN [QUINACRINE] WORKERS I MANN, Brit J Ophth 31 40 (Jan) 1947

The present note concerns the ocular condition of 6 workers engaged in the production of quinacrine (atabrine) and its compression into tablets. Despite the wearing of protective clothing, goggles and masks, the dust was so fine that the workers soon noticed yellow staining of the conjunctivas and skin, especially of the hands, head and neck. After several weeks or months each one noticed that when looking at a small point of light he saw a blue halo around it. Visual acuity was found to be 6/6 in all eyes. In connection with the yellow discoloration in the interpalpebral space, there was a curious slight dulling and yellowing of the cornea. Examination with the slit lamp showed aggregations of minute dark brown dots at the limbus in the exposed portion and just under the edge of the lower lid. The whole surface of the cornea was covered with yellowish brown dustlike particles. The surface was perfectly smooth and bright, so that it seems likely that the particles were situated in the substance of the corneal epithelium. Across the lower part of each cornea was a series of wavy yellow lines composed of aggregated dots. No permanent damage appears to have resulted. It is possible that the particles were precipitates of an insoluble breakdown product of quinacrine. The halo was obviously a diffraction effect, due to the opaque granules in the epithelial cells. The article is well illustrated with colored plates.

W ZENTMAYER

Lens

CATARACT GLAUCOMATOSA ACUTA H S SUGAR, Am J Ophth 29: 1396 (Nov) 1946

Sugar reports 6 cases of acute glaucomatous cataract and summarizes the literature. The condition is important chiefly in differential diagnosis and in establishing the diagnosis of a previous attack of acute glaucoma.

W S REESE

CONTRIBUTIONS TO THE SURGERY OF CONGENITAL CATARACT W F MONCREIFF, Am J Ophth 29 1513 (Dec) 1946

Moncreiff suggests discission as the method of choice in cases of congenital cataract, followed by irrigation of the anterior chamber with the fluid directed toward the posterior capsule and the center of the pupil. This is designed to remove cortex from the capsular sac and displace it into the anterior chamber. He does not incise the posterior capsule and emphasizes the need of maximal mydriasis. Three cases are reported.

W S REESE

ECTOPIA LENTIS CONGENITA W P C ZELMAN, Acta ophth 20: 1, 1942

Of 45 eyes with congenital ectopia lentis which had not received any surgical treatment, retinal detachments were found in 5 and cataract in 8. Glaucoma occurred in 5 eyes. Myopic changes in the fundus accounted for the very poor vision in 3 other eyes.

On 17 eyes operation was performed by various methods. Good results were obtained in 13 eyes. Two eyes retained diminished function (15/60 to 5/60), 2 eyes, less than this. The author stresses the complications that occur with various surgical procedures. Everything considered, he favors discussion of the lens with two needles.

O P PERKINS

ELECTRIC CATARACT AND ELECTROCARDIOGRAPHIC CHANGES AFTER SHOCK E. GODTFREDSEN, *Acta ophth* 20: 69, 1942

A case is recorded in which electric shock resulted in changes in the lens in the form of capsular vesicles, which gradually disappeared, leaving a permanent subcapsular opacity with reduced vision.

Electrocardiographic studies disclosed changes suggesting a coronary lesion and signs of disturbance in the conduction system. The importance of early ophthalmic and electrocardiographic examinations in cases of electric shock is pointed out, with special reference to possible claims for compensation.

O P PERKINS

### Neurology

NYSTAGMUS: AN APPRAISAL AND A CLASSIFICATION R. N. DEJONG, *Arch Neurol & Psychiat* 55: 43 (Jan) 1946

DeJong has written an appraisal and classification of the varieties of nystagmus, with an excellent review of the literature, including the important references. He describes nystagmus as to type, form, direction, rate, amplitude, duration and intensity, and as to the relation of the response to movements of the eyes, head and body. He reviews the methods for the delineation and recording of nystagmus.

DeJong states: "Nystagmus must not be regarded as an entity, for there are many types of nystagmus which appear to serve widely diverse purposes. The position of the eyes is influenced reflexly by impulses coming from the retinas, the ocular muscles, the labyrinths and the cochlea and by proprioceptive impulses arising from movements of the head or body. It is also influenced by impulses arising centrally from the motor cortex. Nystagmus may, in most instances, be considered a compensatory reaction of the eyeballs to defective or abnormal impulses arising from any of these sources. It may serve many apparent purposes: namely, to keep the eyes as long as possible in the same position in relation to the visual field, to increase incoming impulses, to aid in ocular fixation, and to assist in orientation in space."

The rapid and the slow component of nystagmus and their significance are discussed, the methods used to induce nystagmus clinically or experimentally, with the interpretation of deviations from normal, are presented.

The pathologic varieties of nystagmus, spontaneous or induced, which are of clinical significance as an expression of disease of the central nervous system, the eyes or the ear are described.

The material in this fourteen page article is concentrated and worth being read in its entirety by all ophthalmologists.

S R IRVINE

DIVERGENCE PARALYSIS ASSOCIATED WITH TUMOR OF THE BRAIN  
N SAVITSKY and M J MADONICK, Arch Neurol & Psychiat  
55 232 (March) 1946

Divergence paralysis associated with brain tumor is reported in 4 cases. In 2 of these cases the tumor was a cerebellar neoplasm and in 2, an acoustic neuroma. The authors feel that divergence paralysis is more frequently present with tumors of the posterior fossa than is indicated in the literature. They believe that this divergence paralysis is in some way the result of involvement of the divergence center in the brain. The divergence paralysis may be inconstant. It disappeared in 3 of the 4 reported cases after successful removal of the tumor.

S R IRVINE

NEUROFIBROMATOSIS WITH DEFECT IN WALL OF ORBIT. REPORT OF  
FIVE CASES. W T PEYTON and D R SIMMONS, Arch Neurol  
& Psychiat 55:248 (March) 1946

Five cases of neurofibromatosis with defect in the orbital wall are presented, and some of the general features of neurofibromatosis are discussed. The neurosurgeons who present these cases feel that defects in the wall of the orbit, permitting free communication between the cranial cavity and the orbit, are not as rare as might be inferred from the paucity of reports concerning it, for they encountered these 5 cases in a ten year period at the University Hospitals of the University of Minnesota.

The exophthalmos in cases of neurofibromatosis may be due to two factors—a retrobulbar neurofibroma or an associated tumor other than neurofibroma, such as glioma of the optic nerve. However, the chief reason for the exophthalmos in the cases reported was encroachment on the orbit by the intracranial contents. In most of these cases a pulsating type of exophthalmos is present, the pulsations being due to transmitted pulsations of the cerebrum.

S R IRVINE

### Ocular Muscles

EXACT MEASUREMENT OF CONVERGENCE AND DIVERGENCE WITH  
PRISMS. A HUDELO, Ann d'ocul 178 148 (April) 1945

The author deplores the simple notation of convergence or divergence weakness or excess. He points out the disadvantages of the Maddox rod in measuring phorias and pleads for the more general use of prisms in the measurement of convergence and divergence. He explains simply how the prisms should be held. The largest letter on the acuity chart is used for fixation. The convergence and divergence can then be written in exact prism diopters. To ophthalmologists in this country, where the use of prisms is so generally accepted, it seems strange that there might be ophthalmologists who would not know how to measure prism convergence or divergence, either with the Risley prism or with loose prisms.

P R McDONALD

### Operations

DUST-BORNE INFECTION IN OPHTHALMIC SURGERY M H Post,  
Am J Ophth 29:1435 (Nov) 1946

Post concludes from his investigations that to prevent infections in an operating room one should observe the following precautions

Keep covers on all solutions, towels, instruments, and the like, as much as possible

Substitute an aqueous solution of zephiran chloride, or similar detergent, for the water bath

Dip all instruments that are actually to enter the eyeball into a suitable sterilizing solution, or boiling water, for at least two and one-half seconds immediately before use

Install, as soon as practicable, some method for air sterilization in the operating room

Treat all blankets and sheets with some type of oil solution

Treat the floor of the operating room with some type of dust-allaying preparation

Since these investigations started, approximately 600 intraocular operations have been performed, yet only 1 instance of infection has occurred, and in this case the precaution of dipping the instruments immediately before use, through a misunderstanding, was not observed

W S REESE

### Orbit, Eyeball and Accessory Sinuses

DETERMINATION OF OCULAR TENSION AND RIGIDITY IN RABBITS  
E SCHMERL and B STEINBERG Am J Ophth 29:1400 (Nov)  
1946

Schmerl and Steinberg made tonometric determinations of the impressibility of the wall of eyes of rabbits over a prolonged period. The tension and the rigidity were then deduced. Determinations were made at different periods of the day, after instillation of paredrine hydrobromide (para-hydroxy- $\alpha$ -methylphenylethylamine hydrobromide), atropine and pilocarpine and after ingestion of isotonic, hypotonic and hypertonic solutions of sodium chloride. Average values, standard deviations and significant differences were determined

W S REESE

PROGRESSIVE EXOPHTHALMOS M T BARDRAM, Acta ophth 22:1,  
1944

The literature dealing with malignant exophthalmos is surveyed. Three additional cases are reported, in each of which there was an increased output of gonadotropic hormone in the urine. In 1 case the basal metabolic rate was elevated, although there were no other signs of thyrotoxicosis. The pathogenesis is discussed, the author concluding that the disease is caused by a disturbance in hormone correlation arising after removal of the thyroid gland

O P PERKINS

## Pharmacology

ALKALINE EYE DROPS AND THEIR STABILITY C J BLOK, *Ophthalmologica* 108: 217 (Oct-Nov) 1944

The author discusses the advantages of alkaline solutions of drugs to be used in the eye. Because of better penetration, such medicaments are active at lower concentrations of the active ingredients. Alkaline solutions of pilocarpine hydrochloride are stable for about six weeks and solutions of homatropine hydrobromide for about three weeks. With solutions of scopolamine hydrobromide the addition of a mannite solution allows an economy of the alkaloid, owing to better absorption. As a preservative, the addition of 0.03 per cent "nipasol" (a para-hydroxybenzoate) or 1 drop of chloroform per 10 cc is recommended.

F H ADLER

## Retina and Optic Nerve

THE EFFECTS OF ATABRINE [QUINACRINE] ON THE HUMAN VISUAL SYSTEM L R DAME, *Am J Ophth* 29: 1432 (Nov) 1946

Dame concludes from his investigation that although scotomas and enlargement of the blindspots accompanied suddenly attained high atabrine levels of quinacrine (atabrine) in the blood they disappeared with the lowering of these levels.

W S REESE

ACUTE SPONTANEOUS AND POSTOPERATIVE HYPOTONY IN RETINAL DETACHMENT I PORSAA, *Acta ophth* 20: 379, 1942

The author describes the acute hypotony occurring in cases of retinal detachment, he points out that the condition is the same as that observed as a postoperative complication following diathermy procedures and that a perforating injury of the eyeball may produce an exactly similar clinical picture. He suggests that the hypotony may be due to a concomitant lesion of the choroid, resulting in free passage of fluid from the vitreous through retinal and choroidal ruptures to the suprachoroidal space. This would explain the diminished tension and the increased depth of the anterior chamber, while hemorrhage from the choroidal lesion would explain the greenish discoloration of the iris, the opacities in the vitreous and the cloudiness of the aqueous. Detachment of the ciliary body might account for the pain and irritation that sometimes occur.

O P PERKINS

TREATMENT OF THROMBOSIS OF THE VEINS OF THE RETINA WITH HEPARIN K G PLOMAN, *Acta ophth* 21: 190, 1944

Thirty-eight patients with thrombosis of the central vein and 31 patients with branch thrombosis were treated with heparin and followed up for an adequate period, i. e., an average of about two years.

The percentage of patients with good final vision was slightly higher than that for an untreated group of patients reported by Odquist. The author warns that treatment is of no use in cases in which increased tension has occurred or in which the papilla is wholly obliterated by massive hemorrhages extending far out toward the periphery and concealing the macular region.

O P PERKINS

## Tumors

MALHERBE'S EPITHELIOMA REPORT OF A RARE CASE P S BORROTO,  
Rev Col. med. de Cienfuegos 1:1 (Nov-Dec) 1945

The case is presented of an 11 year old child, showing a neofornation of the lower lid, the size of a bean, slightly movable, painless, yellow and without any relation to the malai bone or the upper jaw The differential diagnosis is analyzed Microscopic examination of a biopsy specimen revealed a calcified Malherbe epithelioma This is a rare neoplasm of benign prognosis, with a tendency to recurrence, but it never metastasizes

M E ALVARO

PRIMARY SYPHILOMA OF THE LIDS B P SANTOS, Soc de oftal de  
São Paulo, May 14, 1945

The condition was diagnosed as primary syphiloma (protosyphiloma) of the lid There were pronounced edema of the lids and bulbar conjunctiva and slight reaction of the preauricular glands The submaxillary and cervical glands were swollen The Wassermann reaction was positive The differential diagnosis of sporotrichosis, tuberculosis and a possible neoplasm is made The appearance, characteristic hardening, glandular reaction, positive Wassermann reaction and regression of the process under treatment all point to the diagnosis of primary syphiloma of the lids

M E ALVARO

## Uvea

POSTERIOR UVEITIS IN A CASE OF SARCOIDOSIS F R NEUBERT, Brit  
J Ophth 30:724 (Dec) 1946

A man aged 24 gave a history of radical mastoidectomy at the age of 2 and of malaria at the age of 7 years Both fundi showed coarse, disseminated chorioidal scarring, with some fresh patches of chorioidal exudate The biomicroscope revealed interstitial scarring and opacities in the vitreous At the age of 29 military tuberculosis of the lungs was present Abdominal symptoms developed, and operation revealed constrictions of the cecum with a well marked "string sign," typical of regional ileitis The cecum was resected, and microscopic examination of a section showed a picture typical of sarcoidosis

W ZENTMAYER

ANATOMICOCLINICAL STUDY OF CERTAIN FORMS OF BESNIER-BOECK-  
SCHAUMANN DISEASE J FERRIE and J GRYNFELTT, Ophthal-  
mologica 112:193 (Oct-Nov) 1946

The authors describe a number of cases which belong to the general class of Mikulicz' disease and cases of Heerfordt's syndrome (uveo-parotid fever) in which the anatomic and clinical examination suggested the possibility of grouping these cases together under a common heading They believe that all the diseases have a common tuberculous basis There is no bacteriologic confirmation of this, and the authors rely for this opinion on the history, the appearance of the lesions, the histologic picture, the reactions to tuberculin and the influence of



tuberculin therapy on the course of the disease. They believe that the disease complex which they have described is due to an atypical tuberculosis.

F H ADLER

#### REEXAMINATION OF CENTRAL RUPTURES OF THE CHOROID E GODT-FREDSEN, *Acta ophth* 20 337, 1942

Twelve patients with central rupture of the choroid were reexamined after varying intervals, the average period being three years. Hole formation in the retina occurred once only, nevertheless, the visual acuity of more than one-half the patients became bad because of retinal changes secondary to subretinal and retinal hemorrhages, or to Berlin's edema.

On the other hand, a choroidal rupture right through the fovea does not necessarily mean that the prognosis is bad. Two patients with such a rupture recovered a visual acuity of 6/6, another, an acuity of 6/12.

If improvement of central vision is to occur, it usually does so in the first few weeks after the accident. No improvement occurs after two months.

O P PERKINS

#### Vision

#### ILLUMINATION STANDARDS M A TINKER, *Am J Pub Health* 36. 963 (Sept) 1946

Tinker points out that codes of lighting have been issued by the Illumination Engineering Society either alone or jointly with the American Institute of Architects. He thinks that a more satisfactory approach to hygienic lighting may be achieved by coordinating the work of engineers, physiologists and psychologists. It is obvious that visual work should not be done at critical levels of illumination. There should be an adequate margin of safety to provide for individual variation. For such visual tasks as reading good-sized print (10 to 11 point) on a good quality paper, 10 to 15 foot candles should provide hygienic conditions for normal eyes. For the reading of newspaper, 15 to 20 foot candles should be adequate. In situations involving the reading of handwriting and other comparable tasks, an intensity of 20 to 30 foot candles seems desirable. For tasks comparable to discrimination of 6 point type there should be an intensity of 30 to 40 foot candles. For the most exacting tasks encountered in workday situations 40 to 50 foot candles will be found adequate. There is no valid experimental work now available which indicates a need for an intensity of illumination over 50 foot candles for adequate visual discrimination. These suggestions hold for school children as well as for adults. Intensity of illumination cannot be prescribed without coordinating it with other factors, such as distribution of light and brightness contrast.

J A M A (W ZENTMAYER)

#### VISUAL HALLUCINATIONS AND THEIR RELATIONSHIP TO OPHTHALMOLOGY JEAN LHERMITTE, *Ann d'ocul* 178:129 (April) 1945

The author states that there are few problems that have aroused as much discussion and about which so much has been written as the subject of hallucinations. He accepts the definition of Ball that a

hallucination is "perception without an object" and distinguishes between an illusion and a hallucination

Hallucinations may be concerned with the perception of elementary colors, flames or fires or with more complex objects, such as persons, animals and figures. One should note whether the perceived object is moving or fixed, colored or not, bidimensional or tridimensional, transparent or opaque, whether it follows the movement of the eyes, whether it is deviated by a prism, suppressed by closing the eyes or accompanied with a change in the visual field

The paper contains a general discussion of the visual pathways, with special reference to subjective disturbances brought about by lesions at the various levels. The author concludes that visual hallucinations are not merely manifestations of a general cerebral disturbance. He believes that careful evaluation of the nature of the hallucinations enables one to localize the lesion fairly precisely in the visual system, i. e., in the retina, the tracts or the cortex

P. R. McDONALD

### Therapeutics

PURE PENICILLIN IN OPHTHALMOLOGY. ARNOLD SORSBY and JOSEPH UNGAR, *Brit. M. J.* 2:273 (Nov. 16) 1946

In their investigations, Sorsby and Ungar followed the general trend of ocular penicillin therapy of using high concentrations of the drug applied topically and massive doses given parenterally, as first suggested by Struble and Bellows. A pure preparation with the potency of 1,660 units per milligram permitted the authors to increase the tolerated dose above that commonly applied in local therapy. They selected the instillation of ointments containing 25,000 to 100,000 units per gram (about fifty times the usual dose) and subconjunctival injections of 25,000 to 50,000 units (about ten times the usual dose). With regard to iontophoresis, the authors referred to the study of Hamilton-Paterson, who raised basic objections against penicillin ionization. It seems timely to point out that the theoretic assumption of Hamilton-Paterson had been proved in great part unsound and that his conclusions were not applicable to corneal iontophoresis.

The experiments on tolerance of ocular tissues to penicillin confirmed the opinion that most of the irritation caused by the drug was due to the presence of impurities. However, this does not fully answer the question of penicillin toxicity, as it was shown recently that the various isolated species of pure penicillin are injurious to the eye in varying degrees. No conclusions can be drawn from the results of Sorsby and Ungar achieved with intraocular injections of penicillin, as the number of observations was too small and histologic examination was not made.

The observations in the study on penetration and distribution of the drug were generally in agreement with those of other workers if the difference in dose is considered. With the ointments and solutions of the aforementioned strength, satisfactory levels of the drug were obtained in the aqueous, whereas in the vitreous only moderate amounts were present. After subconjunctival injection penicillin was absorbed into the blood. No explanation was given for the fact that the penicillin content in the aqueous of the second, untreated, eye reached in

1 instance 4 units per cubic centimeter, whereas the blood levels did not exceed 2 units per cubic centimeter. A solution of epinephrine hydrochloride (1:1,000) added in equal parts to the penicillin fluid in the subconjunctival injection secured higher and better sustained levels in the aqueous. It was not investigated whether the low  $p_H$  of a solution of epinephrine chloride (1:1,000) inactivated any part of the penicillin.

Ointments and subconjunctival injections were employed in the treatment of experimental intraocular infections, mostly produced by a strain of *Staphylococcus aureus*. Infections of the anterior chamber benefited greatly from these therapeutic procedures, as they do from other local treatment. A progressive suppurative process was observed by the authors in 5 control eyes. This observation is in contrast to the unpredictable course of the inflammation after inoculation of the anterior chamber with various strains of pathogenic *Staph. aureus* described in the literature. Ten eyes with staphylococcic infection of the vitreous responded surprisingly well to repeated subconjunctival injections of strong solutions of penicillin. The results cannot be compared with those from other laboratories for several reasons. The susceptibility of the infecting organisms for penicillin was not mentioned, and no histologic examination was reported. The interval between the infection and the first treatment was reduced to two hours, a technic unlike that used in similar studies, in which there was an interval of eight hours or more between inoculation and penicillin therapy. The early treatment of course favored greatly therapeutic success.

Massive systemic administration of commercial penicillin did not give unusual results. Results of intramuscular injections of penicillin with epinephrine or hexamine or in beeswax corroborated the maintenance of adequate blood levels over a prolonged period as mentioned in previous work on this subject. The therapeutic effects of the systemic therapy were not clear, and can hardly be evaluated without histologic reports on the eyes.

In their discussion of the experimental part, the authors stressed the superiority of subconjunctival treatment of infections of the anterior segment of the eyeball and of the vitreous. Two injections of 20,000 to 25,000 units daily for three days were recommended. It is self evident that the results obtained in the experimental animals cannot be applied directly to man. This view appeared justified in consideration of the unsuccessful results of treatment in 6 of 8 patients with postoperative infections and in 3 patients with infections of the vitreous and intraocular foreign bodies. The optimism of the authors with regard to the effectiveness of the recommended method in treatment of severe postoperative infections of the anterior segment, and especially of the vitreous, in human eyes can therefore hardly be shared. Subconjunctival injections introduce a factor of considerable uncertainty, since it cannot be predicted in the individual case whether enough penicillin will permeate the coats of the human globe and diffuse rapidly enough in the vitreous to stop the infection in the initial stage.

L. VON SALLMANN

## Correspondence

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### CORNEAL AND CONJUNCTIVAL PIGMENTATION AMONG WORKERS IN HYDROQUINONE

*To the Editors* —In connection with Dr. Banks Anderson's article, entitled "Corneal and Conjunctival Pigmentation Among Workers Engaged in the Manufacture of Hydroquinone," which appears in this issue of the ARCHIVES, it may be of interest to note our unsuccessful attempts in the Howe Laboratory to produce pigmentation of the cornea and conjunctiva in rabbits and guinea pigs by acute exposure to parabenzoquinone vapor. This is the compound presumably responsible for the pigmentation in human beings. Three albino rabbits and 6 guinea pigs were introduced into an exposure chamber containing solid quinone spread out on a tray, but separated from contact with the animals. The concentrations of parabenzoquinone vapor in the chamber at various times were as low as 2 parts, and as high as 13 parts, per million. The concentration in the plants where Anderson's patients worked varied between 0.01 and 3.2 ppm.<sup>1</sup>

The animals were examined after exposures of four to five days and fifteen days. By the twenty-first day all the animals were dead.

On the fourth day, the corneas showed punctate stippling of the surface, just visible with the low power of the biomicroscope, and punctate "take" with the fluorescein stain. This was similar to, but somewhat more pronounced than, that seen frequently in apparently normal rabbits and guinea pigs. There was no discoloration of the cornea, conjunctiva or nictitating membrane. The white fur of the animals, especially of the nose, feet and abdomen, was colored brown, but the drinking water was also colored brown and may have colored the fur by contact.

By the fifteenth day, 1 of the rabbits and 4 of the guinea pigs were dead. The eyes of the survivors showed somewhat more pronounced stippling and greater staining of the corneas with fluorescein, especially in the palpebral zone but still showed no discoloration. The surviving rabbit and 1 of the surviving guinea pigs which had shown considerable corneal stippling was killed for histopathologic study. The specimens showed only mild keratosis of the corneal epithelium.

DAVID G. COGAN, M.D., and W. MORTON GRANT, M.D., Boston

Howe Laboratory of Ophthalmology, 243 Charles Street

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<sup>1</sup> Oglesby, F. L., Sterner, J. H., and Anderson, B. Quinone Vapors and Their Harmful Effects. II. Plant Exposures Associated with Eye Injuries, J. Indust. Hyg. & Toxicol. 29: 74-84, 1947.

# News and Notes

EDITED BY DR W L BENEDICT

## GENERAL NEWS

**Scholarships Granted by Eye Bank for Sight Restoration**—The Eye Bank for Sight Restoration announces the bestowal of two scholarships. Dr Thomas Duane will investigate the metabolism of the cornea under various conditions of storage at the Howe Laboratory of the Harvard Medical School, and Dr David Freeman will work at the Yale University School of Medicine on an experiment in tissue transplantation.

**Department of Roentgen Therapy, Institute of Ophthalmology, Presbyterian Hospital**—The Institute of Ophthalmology of the Presbyterian Hospital, New York, has recently opened a department devoted to the treatment of ocular diseases and neoplasms with irradiation. The present equipment consists of a high voltage machine, of 220 kilovolts, for the treatment of deeply seated lesions, a low voltage machine, of 120 kilovolts, for more superficial therapy, and a machine of still lower voltage, ranging from 8 to 25 kilovolts, for still more superficial treatment.

**Back Copies of Transactions of the American Ophthalmological Society**—Back copies of volumes of the *Transactions of the American Ophthalmological Society*, from the founding of that society through 1939, are available, with the following exceptions:

Volumes I, IV, part 3, VIII, part 2, XVI, XXXIII, XXXIV, and XXXV. Volumes I through XV, XXI and XXVI are unbound and can be procured at \$3 each. The other volumes are in standard green binding and can be purchased at \$5 each. Orders or requests for information should be addressed to Dr Maynard Wheeler, 30 West Fifty-Ninth Street, New York 19.

## UNIVERSITY NEWS

**Postgraduate Course in Ophthalmology, University of California Medical School**—The faculty of the University of California Medical School announces a postgraduate course in ophthalmology for qualified physicians, Sept 6 to 10, 1948, to be given at the University of California Medical Center, San Francisco, under the sponsorship of the University Extension (Medical Extension), University of California. Complete program and details will be mailed on request to Dr Stacy R. Mettler, head of postgraduate instruction, Medical Extension, University of California Medical Center, San Francisco 22.

## SOCIETY NEWS

**Ophthalmological Society of Australia**—The eighth annual meeting of the Ophthalmological Society of Australia will be held at Perth, Western Australia, on Aug 15 to 21, 1948, in conjunction with the meeting of the sixth congress of the British Medical Association in Australia. The president of the Section on Ophthalmology of the latter is Dr J. Bruce Hamilton, 174 Macquarie, Hobart, Tasmania, and Dr John L. Day, St George's Terrace, Perth, West Australia, is the honorary secretary.

## Book Reviews

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**Principles of the Contact Lens.** By H. Tiessman, M.B., B.S., F.R.C.S. (Eng.), D.O.M.S., and E. A. Plaipe. Price, 10s 6d. Pp. 88, with 40 illustrations. London: Henry Kimpton, 1946.

The authors state that "so far as we are aware, no publication has yet appeared in this country which deals with the principles and uses of these lenses." This book must therefore have preceded by a short time the excellent work "An Introduction to the Prescribing and Fitting of Contact Lenses," by Frank Dickinson and K. G. Clifford Hall, London, Hammond, Hammond & Co., 1946.

This little book is 5/16 inch thick, of which about half is accounted for by the cover. The subjects discussed, which include a description of contact lenses, comparison with spectacles, indications for uses and tolerance, have all been treated in numerous books, articles and papers. The reviewer can think of no reason for publishing this paper as a book, or for its price—more than \$2 at the current rate of exchange.

G. M. BRUCE

**Klinische und erbbiologische Untersuchungen über die Heredoataxien.** By Torsten Sjögren. Acta psychiatrica et neurologica, supplement XXVII. Pp. 200. Copenhagen: Ejnar Munksgaard, 1943.

The unique material of 188 cases of heredoataxias from 118 families was used for the genetic analysis of this disease group. The painstaking mathematical evaluation referring to 3,111 members of the affected families is based on the excellent analysis of the clinical conditions. Of the five groups into which the material is divided, group I (Friedreich's spinal ataxia [hereditary sclerosis, spinal form]) and group III (Marie's cerebellar ataxia [cerebellar hereditary sclerosis]) show the most uniform symptomatology and course of the disease. Group IV contains congenital mild fragmentary forms (*forme fruste*), which do not show any particular tendency to progression. In group I-A and group II less well defined atypical and mixed forms are described.

Prolonged observation over several decades enabled the author to draw definite conclusions about the course of heredoataxias. Progressive mental deterioration, both in Friedreich's spinal ataxia and in Marie's cerebellar ataxia, is noteworthy in the terminal state. Pronounced muscular atrophies were found to be a regular occurrence late in the course of both forms. The early onset of Friedreich's ataxia, at the age of  $13 \pm 0.7$  years, and the late onset of Marie's ataxia, at the age of  $34 \pm 1.9$  years, confirm previous evaluations. The uniformity of the clinical symptoms in various members of the same family was remarkable.

The most important data and conclusions are given in the genetic analysis. After a discussion of the problems involved and the theoretic possibilities, it is calculated that Friedreich's ataxia is probably a recessive monohybrid, whereas Marie's ataxia must be considered a

dominant monohybrid. It can be assumed that the two diseases are different biologic types with reference to their genetic pattern. The occurrence of the two types in the same family was never observed. Particular attention was paid to the distribution of the conditions in the population of Sweden, and the heterozygotes were found to be living in certain distinct areas of the country.

The data of this investigation are lucidly elaborated in tables, and the genetic calculations are presented in a precise way. The material will be valuable in further studies of this important field of clinical neurology.

ERNST HERZ

**Researches on Normal and Defective Colour Vision** By W. D. Wright, Imperial College of Science & Technology, London. Price, \$10. Pp. 376, and index. St. Louis: C. V. Mosby Co., 1947.

This excellent volume contains some of the most important publications on color vision of the past two decades. While it does not solve the fundamental problems of color vision—indeed, it probably poses more problems than it solves—it goes far toward furnishing a more advanced view of problems of color vision and a basis for evaluating theories, old or new, which purport to solve them. It is a book which anyone seriously investigating problems of color vision must read.

The book consists largely of collected and rewritten papers reporting the work done since 1926 under grants from the British Medical Research Council. The eight parts of the book consist of an introduction and a description of colorimetric equipment, five important sections on luminosity, color mixture, discrimination, adaptation and defective color vision, and a terminal discussion of the fundamental response curves.

While most of the material has previously been published in article or monograph form by Wright or one of his co-workers, there is a great advantage in having it brought together, correlated, amended and presented in a sequential form. Each part of the book is preceded by a short statement of the problems and a bibliography for further reading.

The redetermination of the mixture curves of the spectrum seemed at the time one of the most important researches which would lead to international standardization of illuminants and color specification, and Wright has been given great credit for this work. Of his later work, the investigations on adaptation, binocular matching, retinal pigmentation and foveal color vision promise great assistance to those whose field is the intricate process of retinal physiology. The inclusion of Pitt's work on dichromatism is a valuable and clarifying portion of the discussion of defective color vision. In particular, the localization of the isopunctal areas for protanopic, deutanopic and tritanopic subjects on the ICI diagram is of immense assistance to laboratory students who are using pigment stimuli in the study of defective color vision, as well as of color aptitude.

If one could ask for more from this book, it would be the inclusion of actual data instead of curves. For those who wish or need to make transformation on the ICI diagram, the availability of the basic (or transformed) Wright data would frequently be useful.

"Researches on Normal and Defective Colour Vision" is unhesitatingly recommended for reading by all students of color vision physiology

LEGRAND H HARDY

**Ophthalmic Literature.** Sir Stewart Duke-Elder, Editor Vol I, No 1 Pp 104 Issued quarterly London, England British Journal of Ophthalmology, Limited

A new abstract journal has appeared in English under the title *Ophthalmic Literature* and is sponsored by the *British Journal of Ophthalmology*. It will work in association with the abstracting service of the British Medical Association for general medical literature, and abstracts will be exchanged with *Ophthalmologica Ibero Americana*. In addition to the abstracts from ophthalmic journals, it will bring articles with ophthalmic bearing to be found in journals on general medicine, surgery and pathology, as well as in the more purely scientific periodicals on optics, physics, physiology and biochemistry. In addition, general review articles on important subjects will appear from time to time.

This new journal will appear quarterly, with the year running from June to June, the abstracts beginning with articles published from Jan 1, 1947, and there will be a cumulative annual index.

The editor is Sir Stewart Duke-Elder, and the editorial board includes A G Gross, A J B Goldsmith, A G Leigh, Arthur Lister, A Seymour Phipps and Katherine Tansley.

To the reviewer, the requisites of an abstract journal consist in the proper selection of articles from ophthalmology and from its neighboring departments, and in the availability of the abstracters, who not only must be conversant with the subject but must be able to pick out the salient features of the article in question. This takes time and requires ability and industry.

The contents of the first number show that these conditions have all been met. The field has been well covered, the task of the abstracter is well done, and the subject of the review article, which in this issue is "Penicillin in Ophthalmology," is admirably covered.

Congratulations are offered to the editor and to his board on the appearance of their first number, with every good wish for the future success of this laborious and courageous undertaking.

ARNOLD KNAPP

**May's Manual of Diseases of the Eye** Edited by Dr Charles A Pereira Nineteenth edition Price, \$4 Pp 521, with 387 illustrations, some in color Baltimore Williams & Wilkins Company, 1947

This new edition has been thoroughly revised and brought up to date. It is stated in the preface that the additions consist in penicillin therapy, the modern theory of color vision and its anomalies, thyrotropic and thyrotoxic exophthalmos, congenital cataract following maternal rubella and ocular brucellosis.



Dr May's popular textbook is kept up to date by the energy of its present editor, Dr Charles A. Perera, and should continue its popularity and serve as a reliable and practical introduction to the practice of ophthalmology. Though a number of illustrations have been replaced, most of the remaining black and white illustrations have outlived their distinctness, and the presswork is poor.

ARNOLD KNAPP

**Physiologie oculaire clinique** By A. Magitot. Price, 750 francs. Pp. 458, with 235 illustrations. Masson & Cie, Paris, 1946.

The author has been interested for the last quarter of a century in ocular physiology, particularly in the field of ocular tension and in the retina and iris. He retired in 1940 from active duty in the Lariboisière Hospital, of Paris, where he had succeeded Victor Morax and Poulard, and was able to devote the next four or five years to collecting his papers and writing this excellent book. There was a distinct need for it, since no similar textbook was available in French except Nicati's, which is both out of print and out of date.

This book is written by and for the practicing ophthalmologist, and physiology is approached with a constant view to the explanation of clinical facts. Conversely, clinical facts are used to support and enlighten physiologic theories. If the book had been written by a "pure" physiologist, and not by a practicing ophthalmologist interested in physiology, it would probably have been slightly different. As it is, it makes excellent reading and is a most useful textbook for reference.

The first few chapters are devoted to the lids, ocular sensitivity and the autonomic nervous system of the eye. Next comes the most personal part of the book, for most of the author's previous publications had dealt with the nutrition of the eye, the intraocular fluids and ocular tension. Anyone familiar with these previous papers can readily guess that little importance is given to filtration and to the pathology of the angle in the regulation and anomalies of ocular tension. Although many may not agree with the author, none can read his views without interest, for they are coherent, clearly stated and supported by experimental work and by a complete knowledge of the literature up to the war.

The following chapters deal with the cornea, the iris, the pupil and the lens. They are complete and up-to-date. Then comes a hundred pages on the physiology of the retina, which to the reviewer's mind is probably the best part of the book. This subject is approached in the light of the dual theory (cones for vision in broad daylight, rods for vision in reduced illumination). But even if all readers do not accept this view, they will find all that is known on the retina and its physiology. They can easily transpose this to their own plane of reference.

The book continues with the physiology of the nerve fibers and of the receptor area in the brain. This leads to a study both of the visual field and of the neurologic symptoms related to lesions of the occipital lobe. The last chapters are devoted to ocular muscles and binocular vision.

There are over two hundred illustrations, and numerous references appear at the end of each chapter. Physiologic optics has deliberately been left aside.

EDWARD HARTMANN, M.D.

**Ocular Therapeutics.** By William J Harrison Price, \$3 50 Springfield, Ill. Charles C Thomas, Publisher, 1947

Dr Harrison's small textbook aims to be an accessible reference book for ophthalmic prescriptions. It serves the double purpose of giving help in writing prescriptions and of giving the indications for their use. The drugs selected are those that have stood the test of experience and are official in the United States Pharmacopeia, with one exception (paredrine hydrobromide), and are accepted by the Council on Pharmacy and Chemistry.

The reader will find useful information on isotonic solutions, buffer solutions, the application of moist heat and moist cold, astringents, caustics, antiseptics, mydriatics, cycloplegics and miotics. The author still believes in silver nitrate and in mercury bichloride solution but rejects yellow mercuric oxide, boric acid and ichthammol. The treatment of acid burns and alkaline burns is also given. Short chapters on foreign proteins, old tuberculin, vitamins, sulfonamide drugs and penicillin conclude the book. These, in the reviewer's opinion, are too condensed in view of their importance.

Every physician has his favorite remedies with which the desired results are obtained, so that practice is often a personal matter, at the same time, the proper administration of the remedy must not be overlooked in testing the efficiency of treatment.

With the author's desire for condensation, a number of omissions have occurred which in the opinion of the reviewer would otherwise enlarge the book's usefulness.

The book is splendidly printed, on excellent paper. Its teaching is sound, and the young specialist will find a reliable guide for this important part in the treatment of ocular diseases.

ARNOLD KNAPP

**Documenta ophthalmologica** Edited by F P Fischer, Utrecht, Netherlands, A J Schaeffer, Los Angeles, and Arnold Sorsby, London. Pp 482. Zurich Switzerland. Documenta Press, 1938.

This new journal is to bring monographs treating questions and problems which have been solved to a certain extent, in other words, it presents an up-to-date treatment of the problems in question and should be a complement to the library of the specialist. In volume 1, printed in 1938, and which is in stock, papers on these subjects appeared: Processes of Adaptation in the Vertebrate Retina in the Light of Recent Photochemical and Electrophysiological Research, R Granit, Helsingfors, Finland, Der Wasserhaushalt des Auges und seiner Teile, F P Fischer, Utrecht, Netherlands, La circulation rétinienne, P Baillhard, Paris, Die Bedeutung der Carotinoide für die Augen, P Karrer, Zurich, Switzerland, Le vitamine nei loro rapporti con l'oftalmologia, A Juhász-Schaffer, Milan, Italy, Symptomatologie du glaucome et le problème pathogénique, A Magitot, Paris, and Le problème physico-chimique de l'opacification du cristallin, J Nordmann and P Reiss, Strasbourg, France.

Volume 2 is in process of production and will be published by Dr W Junk, Amsterdam, Netherlands.

ARNOLD KNAPP

**A Hand-Book of Ocular Therapeutics** By the late Sanford R. Gifford, M D, revised by Derrick Vail, M D. Fourth edition. Price, \$5. Pp 336, with 66 illustrations. Philadelphia. Lea & Febiger, 1947.

The last edition of Gifford's "Hand-Book of Ocular Therapeutics" appeared in 1942, so a revision is timely. This task, and the incorporation of new material which was made necessary by progress along certain lines, fell to Dr. Derrick Vail, who was assisted by Dr. F. C. Cordes in the revision of the chapter on "Specific and Non-Specific Protein Therapy," on parts of the chapter on "Physical Therapy" and on all of the chapters on "Diseases of the Optic Nerves and Central Visual Pathways." Dr. J. G. Bellows has been helpful in revising and bringing up to date the information on the sulfonamide drugs and the antibiotic substances. It seemed wisest to defer the introduction of the new antihistamine agents until further knowledge is gained. The chapter on "Disorders of the Muscular Apparatus" has been omitted, with perfectly correct reasoning. It is always difficult to decide on the selection of topics for a book on therapeutics, as many are better treated in the regular textbook or in a special volume.

The rest of the book is unchanged, and, with the characteristic style and personality of the lamented author, its excellent qualities are maintained.

Dr. Vail and his associates are to be congratulated on the appearance of the new edition of this book, which will continue to be essential to every practicing ophthalmologist.

ARNOLD KNAPP

**Bulletins et mémoires de la Société française d'ophtalmologie** 1940-1946. Pp 411. Paris. Masson & Cie, 1946.

The report for this year, entitled "Les aspects pathologiques du fond de l'oeil dans les affections de la rétina (Atlas ophtalmoscopique)," was presented before the *Société française d'ophtalmologie* by Gabriel Renard on May 8, 1939, and, as is customary, was published as a separate volume (reviewed in the *ARCHIVES* 38. 129 [July] 1947). This report is the thirteenth in this remarkable series of monographs on the ophthalmoscopic examination of the fundus oculi, which has added so much to the renown of the French Ophthalmological Society. This volume of the transactions of the society brings the discussion on this report, which took place on May 21, 1946, at the postponed meeting of the society. The remainder of the meeting was occupied with the presentation of about sixty papers concerned with clinical observations on many subjects and their discussion. Among these papers, attention may be drawn to the following: "Intravenous Injections of Procaine in Treatment of Thrombosis of the Retinal Veins," by Schiff-Wertheimer and Gaillard, "Corneal Grafting," "Cataract," "Glaucoma," "Clinical Proof of Permeability of the Blood-Ocular Barrier to Fluorescein," by Amsler, "Retinal Adaptation," by Jayle and Durgaud, and "Postoperative Complications of Operations for Retinal Detachment," by Schiff-Wertheimer and Frileux.

The society is again in full activity, and it is to be hoped that there will be no further interruption in its yearly meetings.

ARNOLD KNAPP

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